CHAPTER 26

Managing Risk

Life is punctuated by unforeseen and unforeseeable shocks. Wars, banking and currency crises, political upheavals, pandemics, and natural catastrophes such as earthquakes and floods can all cause severe economic disruption. For example, if you want to make your hair stand on end, look at Table 26.1, which lists some of the greatest macroeconomic disasters in the past 100 years.[1]

Major catastrophes such as those in Table 26.1 are, fortunately, rare. However, most companies are hit from time to time by potentially ruinous shocks. Good managers try to ensure that their companies are not overwhelmed by them. They check that their company has reserve borrowing power to tide them over difficult periods, they maintain sufficient liquid assets to protect the firm from a possible banking or currency crisis, and they ensure that the firm is not overly dependent on a single source of materials or a single outlet for its products.

Most of the time we take risk as God-given. A company's 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 other than to ensure that the business is not overwhelmed.

That's not wholly true. The manager can avoid some risks. We have already come across one way to do so: Firms can 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 then 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.

[1] R. Barro and J. F. Ursua, "Rare Macroeconomic Disasters," *Annual Review of Economics* 4 (2012), pp. 83–109.

Country	Event	Trough Year	Decline in Real GDP per Head (%)
Argentina	Currency crisis	2002	–22
Chile	Pinochet revolution	1975	–24
Germany	Aftermath of WWII	1946	–74
Greece	WWII	1942	–66
Indonesia	Asian currency crisis	1999	–16
Japan	WWII	1944	–50
Russia	Revolution	1921	–62
Spain	Civil war	1938	–31
United States	Great depression	1933	–29
Venezuela	Maduro government	2018	–62Est

TABLE 26.1 Major economic disasters

26-1 Why Manage Risk?

Financial transactions undertaken *solely* to reduce risk do not add value in perfect and efficient 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.[2] If next winter's price of heating oil turns 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

[2]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.

themselves against price fluctuations and would *not* benefit from the price rise, the hand-rubbing by investors turned to hand-wringing.[3]

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.[4]

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.[5]

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

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[3]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.

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

[5]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 cannot be set against earlier tax payments but can only 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.

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.[6]

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?

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[6]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. "Going for broke" is often called "gambling for redemption."

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.[7] Eighty-three percent of the companies employ derivatives to control interest rate risk. Eighty-eight percent use them to manage currency risk, and 49% 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.[8]

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Derivatives usage
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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.

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 generally use insurance policies to reduce their diversifiable 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 in 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

[7]International Swap Dealers Association (ISDA), "2009 Derivatives Usage Survey," **www.isda.org.**

[8]See P. Tufano, "The Determinants of Stock Price Exposure: Financial Engineering and the Gold Mining Industry," *Journal of Finance* 53 (June 1998), pp. 1015–1052; and G. D. Haushalter, "Financing Policy, Basis Risk and Corporate Hedging : Evidence from Oil and Gas Producers," *Journal of Finance* 55 (February 2000), pp. 107–152.

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.[9] 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.

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, the attack on the World Trade Center on September 11, 2001, cost insurance companies about $36 billion; the Japanese tsunami involved payments of $35–$40 billion; Hurricanes Katrina, Harvey, and Irma are each estimated to cost companies in excess of $40 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.[10] For example, in 2017, the insurance company, Swiss Re, issued $925 million worth of Cat bonds. The bonds cover the company for three years against any losses from earthquakes in California.

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[9]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 $100,000/(1 + r)$.

[10]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 (April 2005), pp. 84–95; K. Froot, "The Market for Catastrophe Risk: A Clinical Examination," *Journal of Financial Economics* 60 (2001), pp. 529–571; and J. D. Cummins, "CAT Bonds and Other Risk-Linked Securities: State of the Market and Recent Developments," *Risk Management and Insurance Review* 11 (Spring 2008), pp. 23–47.

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. A hefty portion of its revenue comes from Pemex, the state-owned oil company. So, when oil prices fall, the government may be compelled to reduce its planned spending.

The government's solution has been to arrange an annual hedge against a possible fall in the oil price. Although the details of its hedging program are a closely guarded secret, it is reported that in 2017 the Mexican government bought put options that gave it the right to sell about 250 million barrels of oil over the coming year at an exercise price of $46 per barrel. If oil prices rose above this figure, Mexico would reap the benefit. But if oil prices fell below $46, the payoff to the put options would exactly offset the revenue shortfall. In effect, the options put a floor of $46 a barrel on the value of its oil. Of course, the hedge did not come free. The Mexican government was said to have spent $1.25 billion to buy the contracts from a group of international banks.

Figure 26.1 illustrates the nature of Mexico's insurance strategy. Panel *a* shows the revenue derived from selling 250 million barrels of oil. As the price of oil rises or falls, so do the government's revenues. Panel *b* shows the payoffs to the government's options to sell 250 million barrels at $46 a barrel. The payoff on these options rises as oil prices fall below $46 a barrel. This payoff exactly offsets any decline in oil revenues. Panel *c* shows the government's total revenues after buying the put options. For prices below $46 per barrel, revenues are fixed at 250 × $46 = $11,500 million. But for every dollar that oil prices rise above $46, revenues increase by $250 million. The profile in panel *c* should be familiar to you. It represents the payoffs to the protective put strategy that we first encountered in Section 20-2.[11]

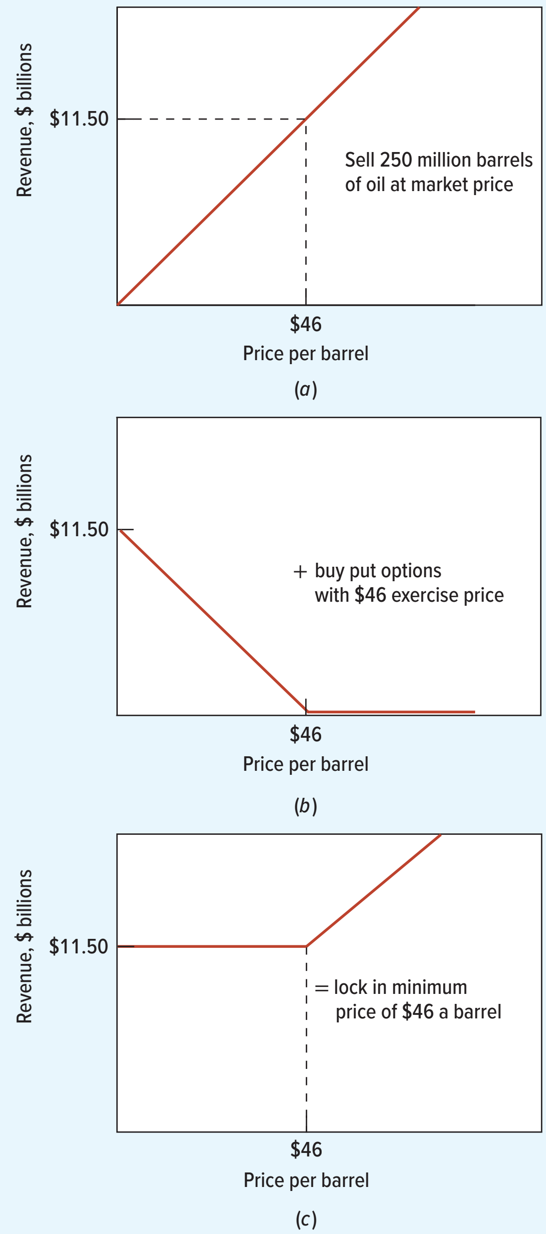

FIGURE 26.1 How put options protected Mexico against a fall in oil prices

[11]The Mexican government option position was slightly more complicated than our description. On some of the production, it agreed to take a hit if prices fell below some minimum price.

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 $2.40 per gallon, to be paid on delivery in January. Northern agrees to sell and deliver one million gallons to Arctic in January at $2.40 per gallon.

Arctic and Northern are now the two *counterparties* in a forward contract. The **forward price** is $2.40 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.

We can think of each counterparty's long and short positions in balance-sheet format, with long positions on the left (asset) side and short positions on the right (liability) side.

Northern Refineries

Long:	Short:
Future production = 1 million gallons	Forward contract to sell at $2.40 per gallon

◄ Forward contract ►

Arctic Fuels

Long:	Short:
Forward contract to buy at $2.40 per gallon	Will require 1 million gallons

Northern Refineries starts with a long position because it will produce heating oil. Arctic Fuels starts with a short position, because it will have to buy to supply its customers. The forward contract creates an offsetting short position for Northern Refineries and an offsetting long position for Arctic Fuels. The offsets mean that each counterparty ends up locking in a price of $2.40, regardless of what happens to future spot prices.

Do not confuse this forward contract with an option. Arctic does not have the option to buy. It has committed to buy at $2.40 per gallon, even if spot prices in January turn out much lower than this. 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 $2.40 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.

BEYOND THE PAGE

The pros and cons of hedging airline fuel costs

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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.

Table 26.2 lists a few of the most important commodity futures contracts and the exchanges on which they are traded.[12] Our refiner and distributor can trade heating-oil futures

Future	Exchange	Future	Exchange
Corn	CBOT, DCE	Aluminum	LME, SHFE
Wheat	CBOT	Copper	COMEX, LME, MCX, SHFE
		Gold	COMEX, MCX
Palm oil	CME, DCE	Lead	LME, MCX
Soybeans	CBOT, TGE	Nickel	LME, MCX
Soybean meal	CBOT, DCE	Silver	COMEX, MCX, TOCOM
Soybean oil	CBOT, DCE	Tin	LME
		Zinc	LME, MCX, SHFE
Live cattle	CME		
Lean hogs	CME	Crude oil	ICE, MCX, NYMEX, TOCOM
		Gas oil	ICE, NFX
Cocoa	ICE, NYMEX	Heating oil	ICE, NYMEX
Coffee	ICE	Natural gas	ICE, NYMEX
Cotton	ICE	Unleaded gasoline	ICE, NYMEX, TOCOM
Lumber	CME		
Orange juice	ICE	Electricity	NYMEX
Rubber	SHFE, TOCOM		
Sugar	ICE, NYMEX, ZCE		

TABLE 26.2 **Some important commodity futures and some of the exchanges on which they are traded**

Key to abbreviations:

CBOT	Chicago Board of Trade (part of CME Group)	MCX	Multi Commodity Exchange (India)
CME	Chicago Mercantile Exchange	NYMEX	New York Mercantile Exchange (part of CME Group)
COMEX	Commodity Exchange Division (part of CME Group)	SHFE	Shanghai Futures Exchange
DCE	Dalian Commodity Exchange (China)	TGE	Tokyo Grain Exchange
ICE	Intercontinental Exchange	TOCOM	Tokyo Commodity Exchange
LME	London Metal ExchangeTGE	ZCE	Zhengzhou Commodity Exchange (China)
NFX	Nasdaq FuturesTOCOM		

[12]By the time you read this, the list of futures contracts will almost certainly be out of date because 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, and the following year, the group acquired NYMEX Holdings, which operated the NYMEX and COMEX exchanges. Also in 2007, the Intercontinental Exchange (ICE) acquired the New York Board of Trade and NYSE merged with Euronext, which owned the futures exchange, LIFFE. Six years later, NYSE Euronext was itself acquired by the ICE, which kept Euronext's futures business but split off its stock exchange operation.

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.

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 26.3 lists some important financial futures. Like Table 26.2 it is far from complete. For example, you can also trade futures on the Thai stock market index, the Chilean peso, Spanish 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 2017 the Chicago Mercantile Exchange and the CBOE Futures Exchange began to offer futures contracts on the bitcoin.

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 any profits. For example, suppose that in September Arctic Fuels buys 1 million gallons of

Future	Exchange	Future	Exchange
U.S. Treasury bonds	CBOT	U.S. house prices	CME
U.S. Treasury notes	CBOT		
German government bonds (bunds)	Eurex, ICE	S&P 500 Index	CME
Japanese government bonds (JGBs)	CME, JPX, SGX	French equity index (CAC)	Euronext
British government bonds (gilts)	ICE	German equity index (DAX)	Eurex
U.S. Treasury bills	CME	Japanese equity index (Nikkei)	CME, JPX, SGX
		U.K. equity index (FTSE)	ICE
LIBOR	CME	Euro	CME, Eurex
Euribor	CME, ICE	Japanese yen	CME
Eurodollar deposits	CME, ICE		
Euroyen deposits	CME, SGX, TFX	Bitcoins	CBOE, CME

TABLE 26.3 Some important financial futures and some of the exchanges on which they are traded

Key to abbreviations:

CBOE	CBOE Global Markets	ICE	Intercontinental Exchange
CBOT	Chicago Board of Trade (part of CME Group)	JPX	Japan Exchange Group
CME	Chicago Mercantile Exchange	SGX	Singapore Exchange
Eurex	Eurex Exchange	TFX	Tokyo Financial Futures Exchange

January heating-oil futures contracts at a futures price of \$2.40 per gallon. The next day the price of the January contract increases to \$2.44 per gallon. Arctic now has a profit of $\$.04 \times 1{,}000{,}000 = \$40{,}000$. The exchange's clearinghouse therefore pays \$40,000 into Arctic's margin account. If the price then drops back to \$2.42, Arctic's margin account pays \$20,000 back to the clearing house.

Of course, Northern Refineries is in the opposite position. Suppose it sells 1 million gallons of January heating-oil futures contracts at a futures price of \$2.40 per gallon. If the price increases to \$2.44 cents per gallon, it loses $\$.04 \times 1{,}000{,}000 = \$40{,}000$ 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 \$2.60 per gallon. Then the futures price at the end of the contract will also be \$2.60 per gallon.[13] So Arctic gets a cumulative profit of $(2.60 - 2.40) \times 1{,}000{,}000 = \$200{,}000$. It can take delivery of 1 million gallons, paying \$2.60 per gallon, or \$2,600,000. Its *net* cost, counting the profits on the futures contract, is $\$2{,}600{,}000 - 200{,}000 = \$2{,}400{,}000$, or \$2.40 per gallon. Thus it has locked in the \$2.40 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 \$2.40 per gallon, regardless of the spot price and ending futures price in January.

Northern Refineries suffers a cumulative loss on the futures contract of \$200,000 if the January price is \$2.60. That's the bad news; the good news is that it can sell and deliver heating oil for \$2.60 per gallon. Its net revenues are $\$2{,}600{,}000 - 200{,}000 = \$2{,}400{,}000$, or \$2.40 per gallon, the futures price in September. Again, you can easily check that Northern's net selling price always ends up at \$2.40 per gallon.

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. Therefore, both parties will probably close out their futures positions just before the end of the contract, and take their profits or losses.[14] Nevertheless the NYMEX futures contract has allowed them 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 French 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 French stocks, of course. But she could also buy futures contracts on the CAC index

[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.

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

of French stocks, which are traded on the Euronext exchange. Suppose she buys 15 six-month futures contracts at 5,000. Each contract pays off 10 times the level of the index, so she has a long position of 15 × 10 × 5,000 = €750,000. This position is marked to market daily. If the CAC goes up, the exchange puts the profits into your fund's margin account; if the CAC falls, the margin account falls too. If your pension manager is right about the French market, and the CAC ends up at 5,500 after six months, then your fund's cumulative profit on the futures position is 15 × (5,500 − 5,000) × 10 = €75,000.

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.[15] 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.[16] The following example shows how and why this formula works.

EXAMPLE 26.1 • Valuing Index Futures

Suppose that the six-month CAC futures contract trades at 5,000 when the current (spot) CAC index is 5,045.41. The interest rate is 1% per year (about .5% over six months) and the dividend yield on the index is 2.8 (about 1.4% over six months). These numbers fit the formula perfectly because

$$F_t = 5{,}045.41 \times (1 + .005 - .014) = 5{,}000$$

But why are the numbers consistent?

Suppose you just buy the CAC index for 5,045.41 today. Then in six months, you will own the index and also have dividends of .014 × 5,045.41 = 70.64. But you decide to buy a futures contract for 5,000 instead, and you put €5,045.41 in the bank. After six months, the bank account has earned interest at .5%, so you have 5,045.41 × 1.005 = 5,070.64, enough to buy the index for 5,000 with €70.64 left over—just enough to cover the dividend you missed by buying futures rather than spot. You get what you pay for.[17]

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[15]In the Appendix to Chapter 19, we pointed out that companies effectively earn the after-tax interest rate when they lend and they pay the after-tax interest rate when they borrow. Therefore, when we value the leverage provided by a forward contract, we should also use the after-tax rather than the pretax rate. You will generally see the formula for the value of a forward contract written without a tax term. For convenience we have followed that convention here, but when valuing a forward contract, remember to use the after-tax rate. See S. C. Myers and J. A. Read, Jr., "Real Options, Taxes and Leverage," *Critical Finance Review,* forthcoming.

[16]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.

[17]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:

$$S_6 + yS_0 = S_6 - F_6 + S_0(1 + rf)$$
$$F_6 = S_0(1 + r_f - y)$$

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 $F_t = S_0(1 + r_f - y)^{t/12}$.

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 is[18]

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

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).

EXAMPLE 26.2 • Calculating Net Convenience Yield

In December 2017, the spot price of crude oil was \$57.57 a barrel and the six-month futures price was \$56.91 per barrel. The interest rate was about 1.2% for six months. Thus

$$F_t = S_0\left(1 + r_f + \text{storage costs} - \text{convenience yield}\right)$$
$$\$56.91 = 57.57(1.012 - \text{net convenience yield})$$

So net convenience yield was positive, that is, net convenience yield = convenience yield − storage costs = .0235 or 2.35% over six months, equivalent to an annual net convenience yield of 4.8%. Evidently the convenience yield from having crude oil in the storage tanks was slightly greater than the storage cost of those inventories.

Figure 26.2 plots the annualized net convenience yield for crude oil since 1983. 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. The reverse is true when storage tanks are full to the brim as in 2016.

There is one further complication that we should note. There are some commodities that cannot be stored at all. You cannot easily store electricity, for example. As a result, electricity supplied in, say, six-months' time is 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

[18]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.

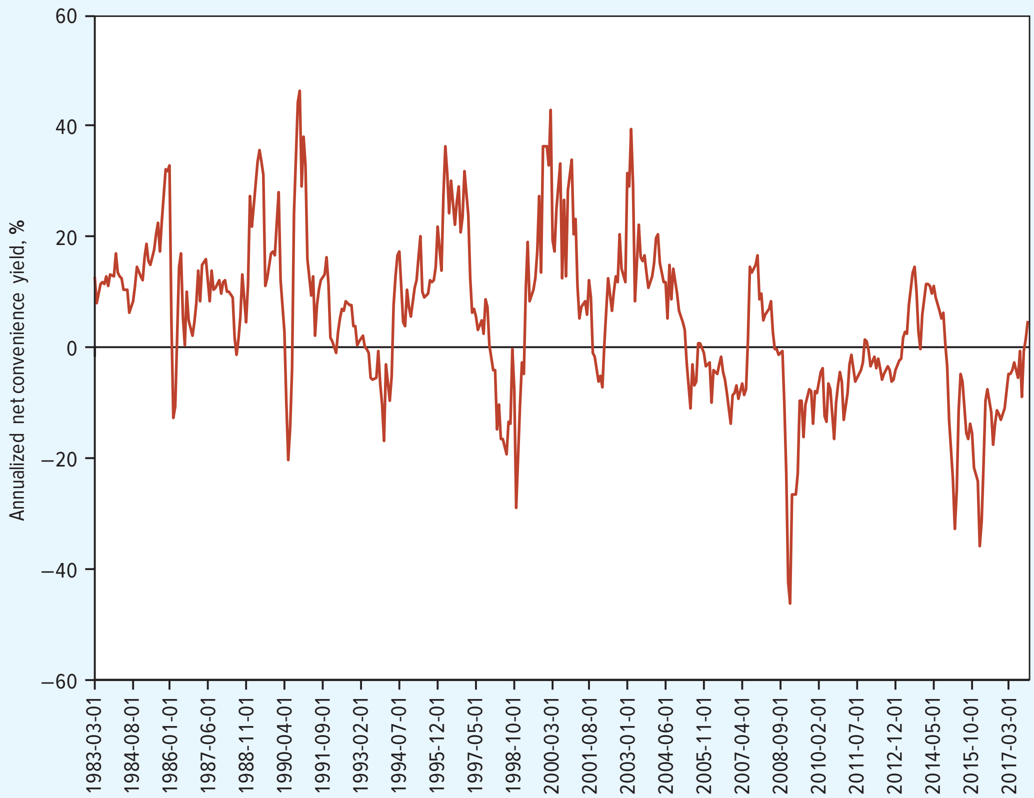

FIGURE 26.2

Annualized percentage net convenience yield (convenience yield less storage costs) for crude oil

Source: **www.quandl.com.**

of what the spot price is likely to be, and the futures price will reveal these views to some extent.[19]

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 this market in Chapter 27.

[19]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.

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.[20] 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, the six-month interest rate is higher than 7%, then the bank will make up the difference;[21] if it is lower, then you must pay the bank the difference.[22]

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:

$$\text{Forward interest rate} = \frac{(1 + \text{2-year spot rate})^2}{1 + \text{1-year spot rate}} - 1$$

$$= \frac{(1.12)^2}{1.10} - 1 = .1404, \text{ or } 14.04\%$$

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 2017, the total notional amount of interest rate and currency swaps outstanding was more than $300 trillion. By far, the major part of this figure

[20]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.

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

[22]These payments would be made when the loan matures nine months from now.

	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	+0.05 × 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
		+0.05 × 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
		+0.05 × 66.67	+ LIBOR_1 × 66.67	+ LIBOR_2 × 66.67	+ LIBOR_3 × 66.67	+ LIBOR_4 × 66.67

TABLE 26.4 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.

consisted of interest rate swaps.[23] We therefore show first how interest rate swaps work and then describe a currency swap. We conclude with a brief look at some other types of swap.

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.[24] 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%.[25] 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 26.4. 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

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

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

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

difference between the interest earned (LIBOR × 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.[26] 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 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.[27] 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%.[28] 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 × 66.67) = \$.67 million:

Bank	◄		0.05 × \$66.67 = \$3.33	◄	Counterparty
Bank		►	\$4	►	Counterparty
Bank		►	Net = \$0.67	►	Counterparty

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

Bank	◄		0.06 × \$66.67 = \$4	◄	Counterparty
Bank		►	\$4	►	Counterparty
Bank		►	Net = 0	►	Counterparty

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

The *notional value* of this swap is \$66.67 million. The fixed and floating interest rates are multiplied by the notional amount to calculate dollar amounts of fixed and floating interest. But the notional value vastly overstates the economic value of the swap. At creation, the economic value of the swap is zero because the NPV of the cash flows to each counterparty is zero. The NPV drifts away from zero as time passes and interest rates change. But the economic value will always be far less than notional value. Careless references to notional values give the impression that swap markets are impossibly gigantic; in fact, they are merely very large.

The economic value of a swap depends on the path of long-term interest rates. For example, suppose that after two years, interest rates are unchanged, so a 6% note issued by the bank would continue to trade at its face value. In this case, the swap still has zero value. (You can

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[26]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.

[27]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.

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

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

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

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 × 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

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

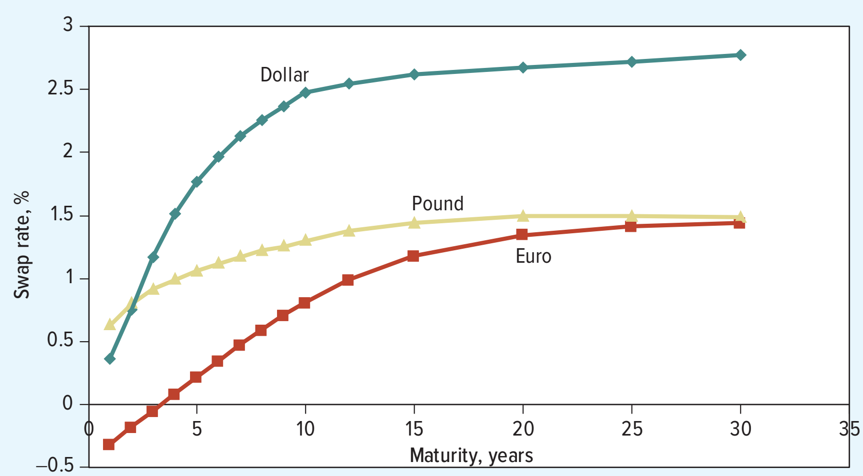
Remember, ordinary interest rate swaps have no initial cost or value (NPV = 0), but their value drifts away from zero as time passes and long-term interest rates change. One counterparty wins as the other loses.

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 rates in December 2017 for the U.S. dollar, the euro, and the British pound. 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, December 2017



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		Year 1–4		Year 5	
Stock	Dollars	Euros	Dollars	Euros	Dollars	Euros
1. Issue dollar loan	+10		−0.6		−10.6	
2. Swap dollars for euros	−10	+8	+0.6	−0.4	+10.6	−8.4
3. Net cash flow	0	+8	0	−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 $.06 \times 10 = \$.6$ 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 €.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.[29]

Some Other 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.

Inflation swaps allow a company to protect against inflation risk. One party in the swap receives a fixed payment while the other receives a payment that is linked to the rate of inflation. In effect, the swap creates a made-to-measure inflation-linked bond, which can be of any maturity.[30]

[29]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.

[30]If the inflation swap involves only a single payment, it is known as a *zero-coupon swap.* If it provides a sequence of payments, each linked to the rate of inflation, it is called a *year-on-year swap.*

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 owes B 6% of $10 million, or about 1.5% a quarter. If IBM stock 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

There can be many ways to hedge a risk exposure. Some hedges are zero maintenance: Once established, the financial manager can walk away and worry about other matters. Other hedges are dynamic: They work only if adjusted at frequent intervals.

The forward contract between Northern Refineries and Arctic Fuels, which we described in Section 26-4, was zero maintenance because each counterparty locked in the price of heating oil at $2.40 per gallon, regardless of the future path of heating-oil prices. Now we look at an example where the financial manager will probably implement a *dynamic hedge.*

Hedging Interest Rate Risk

Potterton Leasing has acquired a warehouse and leased it to a manufacturer for fixed payments of $2 million per year for 20 years. The lease cannot be canceled by the manufacturer, so Potterton has a safe, debt-equivalent asset. The interest rate is 10%, and we ignore taxes for simplicity. The PV of Potterton's rental income is $17 million:

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

The lease exposes Potterton to interest rate risk. If interest rates increase, the PV of the lease payments falls. If interest rates decrease, the PV rises. Potterton's CFO therefore decides to issue an offsetting debt liability:

PV (lease) = $17 million	PV (debt) = $17 million

Thus, Potterton is long $17 million and also short $17 million. But it may not be hedged. Simply borrowing $17 million at some arbitrary maturity does *not* eliminate interest rate risk. Suppose the CFO took out a *one-year,* $17 million bank loan, with a plan to refinance the loan annually. Then she would be borrowing short and lending long (via the 20-year lease), which amounts to a $17 million bet that interest rates will fall. If instead they rise, her company will end up paying more interest in years 2 to 20, with no compensating increase in the lease cash flows.

To hedge interest rate risk, the CFO needs to design the debt issue so that any change in interest rates has the same (and thus offsetting) impact on both the PV of the lease payments and the PV of the debt. There are two ways to accomplish this:

1. *Zero-maintenance hedge.* Issue debt requiring interest and principal payments of exactly $2 million per year for 20 years. This debt would be similar to a real estate mortgage with level payments. In this case, lease payments would exactly cover debt

service in each year. The PVs of the lease payments and the offsetting debt would always be identical, regardless of the level of future interest rates.

2. *Duration hedge*. Issue debt with the same *duration* as the lease payments. Here, debt service does not have to match the lease payments in each (or any) year. If durations are matched, then small changes in interest rates—say, from 10% down to 9.5% or up to 10.5%—will have the same impact on the PVs of the lease payments and the debt.

The duration-matching strategy is usually more convenient, but it is not zero maintenance because durations will drift out of line as interest rates change and time passes. Thus, the CFO will have to revisit and reset the hedge. She will have to execute a dynamic strategy to make duration matching work.

Potterton's CFO first calculates the duration of the lease payments:[31]

$$\begin{aligned}\text{Duration} &= \frac{1}{\text{PV}}\{[\text{PV}(C_1)\times 1] + [\text{PV}(C_2)\times 2] + [\text{PV}(C_3)\times 3] + \cdots\}\\ &= \frac{1}{17.0}\left\{\left[\frac{2}{1.10}\times 1\right] + \left[\frac{2}{1.10^2}\times 2\right] + \cdots + \left[\frac{2}{1.10^{20}}\times 20\right]\right\}\\ &= 7.5 \text{ years}\end{aligned}$$

Therefore, to hedge its interest rate risk, Potterton needs to issue a package of bonds with a duration of 7.5 years. The simplest solution is to issue a 12-year bond with a 10% coupon, which has a 7.5-year duration. But this is not the only possible strategy. For example, the company could issue \$7.9 million of 10% 20-year bonds and \$9.1 million of 10% 8-year bonds. The duration of this package would also be 7.5 years.[32]

Figure 26.4 plots the PVs of the lease payments and the 12-year bond as a function of the interest rate. Both the PV curves are downward-sloping but convex; note how each curve comes down steeply at low interest rates but flattens out at higher interest rates.

Now compare the slope of the PV curve for the lease payments with the slope of the 12-year bond. The slopes are identical at the current 10% interest rate because the duration is identical at this rate. Therefore, so long as the interest rate does not stray too far from the current level of 10%, the PV of the lease cash flows change by almost the same amount as the PV of the bond. In this case, Potterton is hedged. But you can see from Figure 26.4 that if interest rates change by, say, 5%, the value of the lease payments changes by a little bit more than the value of the bond. In this case, Potterton's CFO will have to reset the hedge.

She will also need to reset the hedge at some point even if interest rates do not change because the duration of the 12-year bond will decrease faster than that of the 20-year lease. For example, think forward 12 years: The bond will mature, while the lease will still have 8 years to run.

Duration is not a complete measure of interest rate risk. It measures only exposure to the level of interest rates, not to changes in the shape of the term structure. Duration in effect assumes that the term structure is "flat." It is widely used, however, because it is a good first approximation to interest rate risk exposure. The mini-case at the end of this chapter offers another opportunity to use this concept.

Hedge Ratios and Basis Risk

In our example of Potterton Leasing, the CFO matched lease cash flows worth \$17 million against debt worth \$17 million. In other words, the hedge ratio for Potterton was exactly 1.

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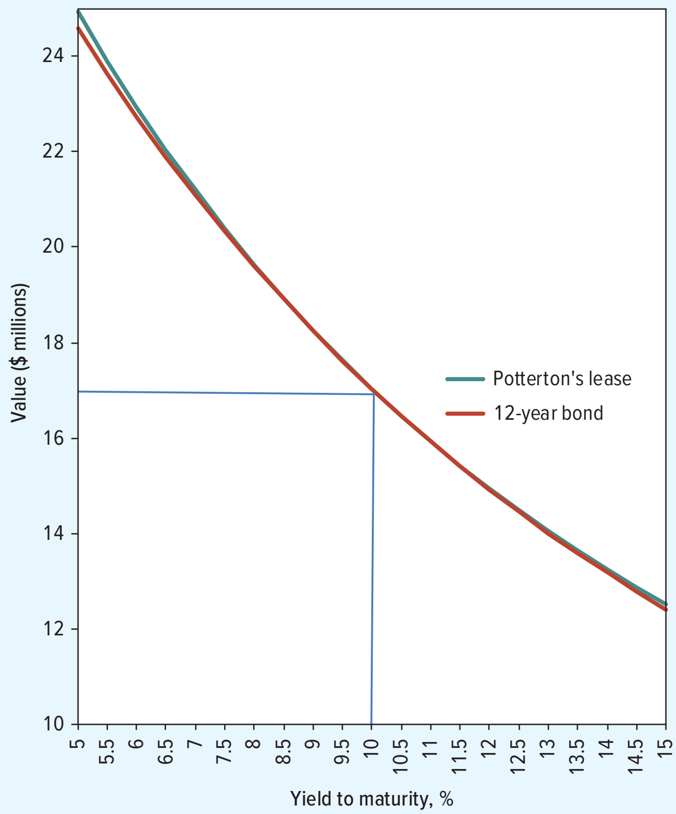
[31] Look back at Section 3-2 if you need a revision session on calculating duration.

[32] The duration of the 20-year bonds is 9.37 years and that of the 8-year bonds is 5.87 years. The duration of the package is $(7.9 \times 9.37 + 9.1 \times 5.87)/17 = 7.5$ years.

FIGURE 26.4

Hedging Potterton's interest rate risk by matching duration. The PV of the lease cash inflows is shown by the blue curve; the PV of a 10% 12-year bond is shown by the red curve. Both have a duration of 7.5 years, so the slopes of the PV curves are identical at the current 10% interest rate. Therefore, Potterton's net exposure to small changes in interest rates is zero.



Hedge ratios can be much higher or lower than 1. For example, suppose a farmer owns 100,000 bushels of wheat and wishes to hedge by selling wheat futures. In practice, the wheat that the farmer owns and the wheat that he sells in the futures markets are unlikely to be identical. 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 26.5 shows how changes in the prices of the two types of wheat may have been related in the past. 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 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:

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

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.

FIGURE 26.5

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, a .8% change in the price of the farmer's wheat.

The trick in setting up a hedge is to estimate the delta or hedge ratio. Our farmer could use past experience to do so, but often a strong dose of judgment is called for. 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 price 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 charging 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 trickier because it 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.

Whenever the two sides of the hedge do not move exactly together, there will be some basis risk. That is not a problem for the CFO of Potterton. As long as interest rates do not change sharply, any changes in the value of Potterton's lease should be almost exactly offset by changes in the value of the debt. In this case there is no basis risk, and Potterton is perfectly hedged.

BEYOND THE PAGE
WTI and Brent oil futures
mhhe.com/brealey13e

Our wheat farmer is less fortunate. The scatter of points in Figure 26.5 shows that it is not possible for the farmer to construct a perfect hedge using wheat futures. Since the underlying commodity (the farmer's wheat) and the hedging instrument (Kansas City wheat futures) are imperfectly correlated, some basis risk remains.

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

Our wheat farmer sold 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 there is an excess of farmers wishing to sell wheat futures, the price

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Major derivatives losses
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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 Beyond the Page feature describes how the French bank Société Générale took a €4.9 billion bath from unauthorized trading by one of its staff. The bank has plenty of company. In 2011, Swiss bank UBS reported that a rogue trader had notched up losses of $2.3 billion. 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 all 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.

An Airbus 380 weighs 400 tons, flies at nearly 600 miles per hour, and is inherently very dangerous. But we don't ground A380s; we just take precautions to ensure that they are flown with 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. You should be equally suspicious if an oil producer or consumer products company announced that it was placing a bet on interest rates or currencies.

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 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 June 2017, the notional value of outstanding derivative contracts was $628 trillion.[33] 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,

[33] Bank for International Settlements, *Derivatives Statistics* (**www.bis.org/statistics/derstats.htm**).

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.[34]

The only meaningful measure of the potential loss from default is the amount that it would cost firms showing a profit to replace their positions.

[34]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 that are 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 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 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 assuming that derivatives are a threat to the financial system.

FURTHER READING

Three general articles on corporate risk management are:

K. A. Froot, D. S. 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:*

J. C. Hull, *Options, Futures, and Other Derivatives,* 10th ed. (Cambridge, England: Pearson, 2017).

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* 2 (Autumn 1984), pp. 41–59.

PROBLEM SETS

Mc Graw Hill Education connect

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

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. **Insurance** 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?
3. **Catastrophe bonds** 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?

4. **Futures and options** A gold-mining firm is concerned about short-term volatility in its revenues. Gold currently sells for \$1,300 an ounce, but the price is extremely volatile and could fall as low as \$1,220 or rise as high as \$1,380 in the next month. The company will bring 1,000 ounces to the market next month.
   a. What will be total revenues if the firm remains unhedged for gold prices of \$1,220, \$1,300, and \$1,380 an ounce?
   b. The futures price of gold for delivery one month ahead is \$1,310. 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?
   c. What will total revenues be if the firm buys a one-month put option to sell gold for \$1,300 an ounce? The put option costs \$110 per ounce.
5. **Futures and options** 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? Assume the current price of oil is \$70 per barrel, the futures price is \$80, and the option exercise price is \$80.
6. **Futures contracts*** 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.
7. **Futures contracts** 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?
8. **Marking to market*** Yesterday, you sold six-month futures on the German DAX stock market index at a price of 13,200. Today, the DAX closed at 13,150 and DAX futures closed at 13,250. 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?
9. **Futures prices** 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.
10. **Futures prices*** In December 2017, six-month futures on the Australian S&P/ASX 200 Index traded at 5,947. Spot was 6,001. The interest rate was 1.8% a year, and the dividend yield was about 4.4% a year. Were the futures fairly priced?
11. **Futures prices** If you buy a nine-month T-bill future, you undertake to buy a \$1 million 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 dollar value of a nine-month bill future?

Commodity	Spot Price	Futures Price	Comments
Magnoosium	$2,550 per ton	$2,728.50 per ton	Monthly storage cost = monthly convenience yield.
Frozen quiche	$0.50 per pound	$0.514 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 26.5 **Spot and six-month futures prices for selected commodities and securities. See Problem 12.**

12. **Futures prices** Table 26.5 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.

13. **Futures prices** The following table shows 2014 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.

	Contract Length (months)		
	3	6	9
Futures price	$1,188.5	$1,189.5	$1,190.0

Calculate the interest rate faced by traders in gold futures, assuming a zero net convenience yield, for each of the contract lengths shown above. The spot price is $1,188.2 per ounce.

14. **Futures prices** Consider the commodities and financial assets listed in Table 26.6. The risk-free interest rate is 6% a year, and the term structure is flat.
    a. Calculate the six-month futures price for each case.
    b. Explain how a magnoosium producer would use a futures market to lock in the selling price of a planned shipment of 1,000 tons of magnoosium six months from now.
    c. Suppose the producer takes the actions recommended in your answer to part (b), but after one month magnoosium prices have fallen to $2,200. What happens? Will the producer have to undertake additional futures market trades to restore its hedged position?
    d. Does the biotech index futures price provide useful information about the expected future performance of biotech stocks?
    e. 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?

Asset	Spot Price	Comments
Magnoosium	$2,800 per ton	Net convenience yield = 4% per year
Oat bran	$0.44 per bushel	Net convenience yield = 0.5% per month
Biotech stock index	$140.2	Dividend = 0
Allen Wrench Co. common stock	$58.00	Cash dividend = $2.40 per year
5-year Treasury note	$108.93	8% coupon
Westonian ruple	3.1 ruples = $1	12% interest rate in ruples

TABLE 26.6 **Spot prices for selected commodities and financial assets. See Problem 14.**

f. 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)?

g. 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.

15. **Convenience yield** 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.

16. **Convenience yield** Residents of the northeastern United States suffered record-setting low temperatures throughout November and December 2024. Spot prices of heating oil rose 25%, to over $7 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 2025 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?

17. **Convenience yield** 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?

18. **Convenience yield** In March 2018, six-month bitcoin futures were priced at $7,925. The spot price was $7,946. The six-month interest rate was 1.92%.
    a. What was the convenience yield?
    b. Is your answer to part (a) consistent with what you would expect? Explain.

19. **Interest rate swaps** 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 6.5% 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?

20. **Interest rate swaps** In September 2020, 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.

a. Assume the swap is fairly priced. What is the value of this swap at the time that it is entered into?

b. Suppose that immediately after A has entered into the swap, the long-term interest rate rises by 1%. Who gains and who loses?

c. What is now the value of the swap for each €1,000 of notional value?

21. **Total return swaps** Is a total return swap on a bond the same as a credit default swap (see Section 23-1)? Why or why not?

22. **Hedging** "Speculators want futures contracts to be incorrectly priced; hedgers want them to be correctly priced." Why?

23. **Hedging** "Northern Refineries does not avoid risk by selling oil futures. If prices stay above $2.40 a gallon, then it will actually have lost by selling oil futures at that price." Is this a fair comment?

24. **Hedging** What is meant by "delta" (δ) in the context of hedging? Give examples of how delta can be estimated or calculated.

25. **Hedging*** 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"?

26. **Hedging**

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?

27. **Hedging** 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 $1,300 per ounce.

a. Suppose the spot price of platinum falls to $1,200 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?

28. **Hedging** 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?

29. **Hedging** 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 ($R^2 = .6$).

a. Suppose you own $100,000 of A. How much of B should you sell to minimize the risk of your net position?

b. What is the hedge ratio?

c. Here is the historical relationship between stock A and gold prices:

Average percentage change in A = −.002 + 1.2 (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.

30. Hedging 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 as far as possible against movements in the price of Swiss Roll?

31. Duration hedging* Securities A, B, and C have the following cash flows:

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

a. Calculate their durations if the interest rate is 8%.

b. Suppose that you have an investment of $10 million in A. What combination of B and C would hedge this investment against interest rate changes?

c. Now suppose that you have a $10 million investment in B. How would you hedge?

32. Basis risk* What is basis risk? In which of the following cases would you expect basis risk to be serious?

a. A broker owning a large block of Disney common stock hedges by selling index futures.

b. An 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.

CHALLENGE

33. Interest rate swaps 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%.

a. Is Phillip's stupid to want long-term debt at an interest rate of 9%? It is borrowing from the bank at 7%.

b. 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.

c. What net swap payment will Phillip's make or receive?

d. 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.

FINANCE ON THE WEB

1. The websites of the major commodities exchanges provide futures prices. Calculate 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.)
2. 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.
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.

MINI-CASE

Rensselaer Advisers

You are a vice president of Rensselaer Advisers (RA), which manages portfolios for institutional investors (primarily corporate pension plans) and wealthy individuals. In mid-2018, RA had about \$1.1 billion under management, invested in a wide range of common-stock and fixed-income portfolios. Its management fees average 55 basis points (.55%), so RA's total revenue for 2018 is about .0055 × \$1.1 billion = \$6.05 million.

You are attempting to land a new client, Madison Mills, a conservative, long-established manufacturer of papermaking felt. Madison has established a defined-benefit pension plan for its employees. RA would manage the pension assets that Madison has set aside to cover defined-benefit obligations for retired employees.

Defined benefit means that an employer is committed to pay retirement income according to a formula. For example, annual retirement income could equal 40% of the employee's average salary in the five years prior to retirement. In a defined-benefit plan, retirement income does not depend on the performance of the pension assets. If the assets in the fund are not sufficient to cover pension benefits, the company is required to contribute enough additional cash to cover the shortfall. Thus, the PV of promised retirement benefits is a debt-equivalent obligation of the company.[35]

Table 26.7 shows Madison's obligations to its already retired employees from 2019 to 2040. Each of these employees receives a fixed dollar amount each month. Total dollar payments decline as the employees die off. The PV of the obligations in Table 26.7 is about $89 million at the current (2018) 5% long-term interest rate. Table 26.7 also calculates the duration of the obligations at 7.87 years.

Madison has set aside $90 million in pension assets to cover the obligations in Table 26.7, so this part of its pension plan is fully funded.[36] The pension assets are now invested in a diversified portfolio of common stocks, corporate bonds, and notes.

TABLE 26.7 **Madison Mills Pension Fund, projected benefits for retired employees**

Year	Date (t)	Payment	PV at 5%	PV × t
2019	1	10,020,000	9,542,857	9,542,857
2020	2	9,009,500	8,171,882	16,343,764
2021	3	8,522,000	7,361,624	22,084,872
2022	4	8,434,500	6,939,084	27,756,336
2023	5	7,858,500	6,157,340	30,786,702
2024	6	7,794,000	5,816,003	34,896,017
2025	7	7,729,500	5,493,211	38,452,479
2026	8	7,639,500	5,170,714	41,365,714
2027	9	6,440,500	4,151,604	37,364,434
2028	10	6,330,000	3,886,071	38,860,709
2029	11	6,242,500	3,649,860	40,148,465
2030	12	6,205,000	3,455,176	41,462,114
2031	13	5,775,500	3,062,871	39,817,322
2032	14	5,600,700	2,828,734	39,602,277
2033	15	5,432,000	2,612,885	39,193,273
2034	16	5,140,000	23,54,693	3,76,75,092
2035	17	4,234,900	1,847,673	31,410,438
2036	18	4,123,000	1,713,192	30,837,450
2037	19	3,890,000	1,539,405	29,248,697
2038	20	3,500,600	1,319,339	26,386,786
2039	21	3,400,500	1,220,584	25,632,254
2040	22	3,340,600	1,141,984	25,123,641
			SUM =	703,991,694
			PV =	89,436,787
			DURATION =	7.87

[35]In *defined contribution* plans, the corporation contributes to the pension fund on behalf of its employees. Each employee has a claim on part of the fund, just as if the employee held shares in a mutual fund. Employees' retirement benefits depend on their balances in the fund at retirement. If the benefits fall short of an employee's plans or expectations, he or she has no recourse to the company.

[36]Madison must also set pension assets aside for current employees. For this mini-case, we concentrate only on retired employees' benefits.

After reviewing Madison's existing portfolio, you schedule a meeting with Hendrik van Wie, Madison's CFO. Mr. van Wie stresses Madison's conservative management philosophy and warns against "speculation." He complains about the performance of the previous manager of the pension assets. He suggests that you propose a plan of investing in safe assets in a way that minimizes exposure to equity markets and changing interest rates. You promise to prepare an illustration of how this goal could be achieved.

Later, you discover that RA has competition for Madison's investment management business. SPX Associates is proposing a strategy of investing 70% of the portfolio ($63 million) in index funds tracking the U.S. stock market and 30% of the portfolio ($27 million) in U.S. Treasury securities. SPX argues that their strategy is "safe in the long run" because the U.S. stock market has delivered an average risk premium of about 7% per year. In addition, SPX argues that the growth in its stock market portfolio will far outstrip Madison's pension obligations. SPX also claims that the $27 million invested in Treasuries will provide ample protection against short-term stock market volatility. Finally, SPX proposes to charge an investment management fee of only 20 basis points (.20%). RA had planned to charge 30 basis points (.30%).

QUESTIONS

1. Prepare a memo for Mr. van Wie explaining how RA would invest to minimize both risk and exposure to changing interest rates. Give an example of a portfolio that would accomplish this objective. Explain how the portfolio would be managed as time passes and interest rates change. Also explain why SPX's proposal is not advisable for a conservative company like Madison.

   RA manages several fixed-income portfolios. For simplicity, you decide to propose a mix of the following three portfolios:

   - A portfolio of long-term Treasury bonds with an average duration of 14 years.
   - A portfolio of Treasury notes with an average duration of 7 years.
   - A portfolio of short-term Treasury bills and notes with an average duration of 1 year.

   The term structure is flat, and the yield on all three portfolios is 5%.

2. Sorry, you lost. SPX won and implemented its proposed strategy. Now the recession of 2019 has knocked down U.S. stock prices by 20%. The value of the Madison portfolio, after paying benefits for 2019, has fallen from $90 million to $78 million. At the same time interest rates have dropped from 5% to 4% as the Federal Reserve relaxes monetary policy to combat the recession.

   Mr. van Wie calls again, chastened by the SPX experience, and he invites a new proposal to invest the pension assets in a way that minimizes exposure to the stock market and changing interest rates. Update your memo with a new example of how to accomplish Mr. van Wie's objectives. You can use the same portfolios and portfolio durations as in Question 1. You will have to recalculate the PV and duration of the pension benefits from 2019 onward. Assume a flat term structure with all interest rates at 4%. (*Hint:* Madison's pension obligations are now *under*funded. Nevertheless, you can hedge interest rate risk if you increase the duration of the pension assets.)

CHAPTER 27

Managing International Risks

The last chapter grappled with risks from changing interest rates and volatile commodity prices. Corporations that operate internationally face still more hazards from currency fluctuations and political risks.

To understand currency risk, you first have to understand how the foreign exchange market works and how currency exchange rates are determined. We cover those topics first, with special emphasis on the linkages between exchange rates and cross-country differences in interest rates and inflation. Then we describe how corporations assess and hedge their currency exposures.

We also review international capital investment decisions. Cash flows for an investment project in Germany, say, must be forecasted in euros, with attention to German inflation rates and taxes. But euro cash flows require a euro discount rate. How should that rate be estimated? Should it depend on whether the investing company is located in the United States, Germany, or another country? Should the discount rate be adjusted for the risk that the euro may fall relative to other currencies? (The answer to the last question is no. The answers to the preceding questions are not so clear-cut.)

We conclude the chapter with a discussion of political risk. Political risk means possible adverse acts by a hostile foreign government, for example, discriminatory taxes or limits on the profits that can be taken out of the country. Sometimes governments expropriate businesses with minimal compensation. We explain how companies structure their operations and financing to reduce their exposure to political risks.

27-1 The Foreign Exchange Market

An American company that imports goods from France may need to buy euros to pay for the purchase. An American company exporting to France may receive euros, which it sells in exchange for dollars. Both firms make use of the foreign exchange market.

The foreign exchange market has no central marketplace. Business is conducted electronically. The principal dealers are the larger commercial banks and investment banks. A corporation that wants to buy or sell currency usually does so through a commercial bank. Turnover in the foreign exchange market is huge. In London in April 2016, $2,406 billion of currency changed hands each day. That is equivalent to an annual turnover of about $878 trillion ($878,000,000,000,000). New York, Singapore, Hong Kong, and Tokyo together accounted for a further $2,625 billion of turnover per day.[1]

[1]The results of the triennial survey of foreign exchange business are published on **www.bis.org/forum/research.htm.**

	Abbreviation	Spot Rate	Forward Rates: 3 Months	6 Months	1 Year
Europe:					
Euro	EUR or €	1.1758	1.1800	1.1845	1.1916
Czech Republic (koruna)	CZK	21.853	21.605	21.549	21.388
Hungary (forint)	HUF	267.28	265.703	264.438	261.520
Poland (zloty)	PLN	3.5773	3.5691	3.5668	3.5618
Russia (ruble)	RUB	58.879	59.453	60.205	61.501
Sweden (krona)	SEK	8.4976	8.4388	8.3886	8.2836
Switzerland (franc)	CHF	.99059	.98222	.97504	.96089
United Kingdom (pound)	GBP or £	1.3321	1.3383	1.3428	1.3520
Americas:					
Brazil (real)	BRL	3.3124	3.3333	3.3664	3.4364
Canada (dollar)	CAD	1.2881	1.2854	1.2841	1.2820
Chile (peso)	CLP	635.93	635.77	636.62	639.14
Mexico	MXN	19.131	19.417	19.728	20.371
Pacific/Middle East/Africa:					
Australia (dollar)	AUD	1.3077	1.3082	1.3084	1.3084
China (yuan)	CNY	6.6076	6.6542	6.6947	6.7668
India (rupee)	INR	64.148	64.358	65.407	66.676
Israel (shekel)	ILS	3.5144	3.5010	3.4854	3.4511
Japan (yen)	JPY or ¥	112.61	111.94	111.34	109.99
New Zealand (dollar)	NZD	1.4294	1.4312	1.4323	1.4339
South Africa (rand)	ZAR	13.180	13.365	13.555	13.942
South Korea (won)	KRW	1,089.2	1,087.3	1,085.7	1,082.1
Turkey (lira)	TRY	3.8676	3.9739	4.0899	4.3306

TABLE 27.1 **Spot and forward exchange rates, December 2017**

Source: CME Group.

[a]Rates show the number of units of foreign currency per U.S. dollar, except for the euro and the U.K. pound, which show the number of U.S. dollars per unit of foreign currency.

Table 27.1 shows a sample of exchange rates in December 2017. Exchange rates are generally expressed in terms of the number of units of the foreign currency needed to buy one U.S. dollar (USD). This is termed an *indirect quote.* In the first column of Table 27.1, the indirect quote for the Brazilian real shows that you could buy 3.3124 reals for $1. This is often written as BRL3.3124/USD1.

A *direct* exchange rate quote states how many dollars you can buy for one unit of foreign currency. The euro and the British pound sterling are usually shown as direct quotes.[2] For example, Table 27.1 shows that GBP1 is equivalent to USD1.3321 or, more concisely,

[2]The euro is the common currency of the European Monetary Union. The 19 members of the Union are Austria, Belgium, Cyprus, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Portugal, Slovenia, Slovakia, and Spain.

USD1.3321/GBP1. If £1 buys \$1.3321, then \$1 must buy 1/1.3321 = GBP.7507. Thus, the indirect quote for the pound is GBP.7507/USD1.[3]

The exchange rates in the second column of Table 27.1 are the prices of currency for immediate delivery. These are known as **spot rates of exchange.** The spot rate for the real is BRL3.3124/USD1, and the spot rate for the pound is USD1.3321/GBP1.

In addition to the spot exchange market, there is a *forward market.* In the forward market you buy and sell currency for future delivery. If you know that you are going to pay out or receive foreign currency at some future date, you can insure yourself against loss by buying or selling forward. Thus, if you need one million reals in three months, you can enter into a three-month *forward contract.* The **forward exchange rate** on this contract is the price you agree to pay in three months when the one million reals are delivered. If you look again at Table 27.1, you will see that the three-month forward rate for the real is quoted at BRL3.3333/USD1. If you buy reals for three months' delivery, you get more reals for your dollar than if you buy them spot. In this case, the real is said to trade at a forward *discount* relative to the dollar because forward reals are cheaper than spot ones. Expressed as an annual rate, the forward discount is[4]

$$4 \times \left(\frac{3.3124}{3.3333} - 1\right) = -.0251, \text{ or } -2.51\%$$

You could also say that the *dollar* was selling at a *forward premium.*

A forward purchase or sale is a made-to-measure transaction between you and the bank. It can be for any currency, any amount, and any delivery day. You could buy, say, 99,999 Vietnamese dong or Haitian gourdes for a year and a day forward as long as you can find a bank ready to deal. Most forward transactions are for six months or less, but the long-term currency swaps that we described in Chapter 26 are equivalent to a bundle of forward transactions. When firms want to enter into long-term forward contracts, they usually do so through a currency swap.[5]

There is also an organized market for currency for future delivery known as the currency *futures* market. Futures contracts are highly standardized; they are for specified amounts and for a limited choice of delivery dates.[6]

When you buy a forward or futures contract, you are committed to taking delivery of the currency. As an alternative, you can take out an *option* to buy or sell currency in the future at a price that is fixed today. Made-to-measure currency options can be bought from the major banks, and standardized options are traded on the options exchanges.

27-2 Some Basic Relationships

You can't develop a consistent international financial policy until you understand the reasons for the differences in exchange rates and interest rates. We consider the following four problems:

- *Problem 1.* Why is the dollar rate of interest different from, say, the rate on Ruritanian pesos (RUPs)?
- *Problem 2.* Why is the forward rate of exchange for the peso different from the spot rate?

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[3]Foreign exchange dealers usually refer to the exchange rate between pounds and dollars as *cable.* In Table 27.1, cable is 1.3321.

[4]Here is an occasional point of confusion. Since the quote for the real is indirect, we calculate the premium by taking the ratio of the spot rate to the forward rate. If we use *direct* quotes, then we need to calculate the ratio of the forward rate to the spot rate. In the case of the real, the forward discount with direct quotes is $4 \times [(1/3.3333)/(1/3.3124) - 1] = -.0251$, or -2.51%.

[5]Notice that spot and short-term forward trades are sometimes undertaken together. For example, a company might need the use of Brazilian reals for one month. In this case, it would buy reals spot and simultaneously sell them forward.

[6]See Chapter 26 for a further discussion of the difference between forward and futures contracts.

- *Problem 3.* What determines next year's expected spot rate of exchange between dollars and pesos?
- *Problem 4.* What is the relationship between the inflation rate in the United States and the inflation rate in Ruritania?

Suppose that individuals were not worried about risk and that there were no barriers or costs to international trade on capital flows. In that case, the spot exchange rates, forward exchange rates, interest rates, and inflation rates would stand in the following simple relationship to one another:

Difference in interest rates		Expected difference in inflation rates
$\dfrac{1 + \text{Ruritanian interest rate}}{1 + \text{U.S. interest rate}}$	equals	$\dfrac{1 + \text{expected Ruritanian inflation rate}}{1 + \text{expected U.S. inflation rate}}$
equals		equals
Difference between forward and spot rates		**Expected change in spot rate**
$\dfrac{\text{Forward peso exchange rate}}{\text{Current peso spot rate}}$	equals	$\dfrac{\text{Expected peso spot rate}}{\text{Current peso spot rate}}$

Why should this be so?

Interest Rates and Exchange Rates

Suppose that you have $1,000 to invest for one year. U.S. dollar deposits are offering an interest rate of 5%; Ruritanian peso deposits are offering (an attractive?) 15.5%. Where should you put your money? Does the answer sound obvious? Let's check:

- *Dollar loan.* The rate of interest on one-year dollar deposits is 5%. Therefore, at the end of the year you get 1,000 × 1.05 = USD1,050.
- *Peso loan.* The current exchange rate is RUP50/USD1. Therefore, for $1,000, you can buy 1,000 × 50 = RUP50,000. The rate of interest on a one-year peso deposit is 15.5%. Therefore, at the end of the year you get 50,000 × 1.155 = RUP57,750. Of course, you don't know what the exchange rate is going to be in one year's time. But that doesn't matter. You can fix today the price at which you sell your pesos. The one-year forward rate is RUP55/USD1. Therefore, by selling forward, you can make sure that you will receive 57,750/55 = $1,050 at the end of the year.

Thus, the two investments offer the same rate of return. They have to—they are both risk-free. If the domestic interest rate were different from the *covered* foreign interest rate, you would have a money machine.

When you make the peso loan, you receive a higher interest rate. But you get an offsetting loss because you sell pesos forward at a lower price than you pay for them today. The interest rate differential is

$$\frac{1 + \text{Ruritanian interest rate}}{1 + \text{U.S. interest rate}}$$

And the differential between the forward and spot exchange rates is

$$\frac{\text{Forward peso exchange rate}}{\text{Current peso spot rate}}$$

Interest rate parity theory says that the difference in interest rates must equal the difference between the forward and spot exchange rates:

Difference in interest rates		Difference between forward and spot rates
$\frac{1 + \text{Ruritanian interest rate}}{1 + \text{U.S. interest rate}}$	equals	$\frac{\text{Forward peso exchange rate}}{\text{Current peso spot rate}}$

In our example,

$$\frac{1.155}{1.05} = \frac{55}{50}$$

The Forward Premium and Changes in Spot Rates

Now let's consider how the forward premium is related to changes in spot rates of exchange. If people didn't care about risk, the forward rate of exchange would depend solely on what people expected the spot rate to be. For example, if the one-year forward rate on pesos is RUP55/USD1, that could only be because traders expect the spot rate in one year's time to be RUP55/USD1. If they expected it to be, say, RUP60/USD1, nobody would be willing to buy pesos forward. They could get more pesos for their dollar by waiting and buying spot.

Therefore the *expectations theory* of exchange rates tells us that the percentage difference between the forward exchange rate and today's spot rate is equal to the expected change in the spot rate:

Difference between forward and spot rates		Expected change in spot rate
$\frac{\text{Forward peso exchange rate}}{\text{Current peso spot rate}}$	equals	$\frac{\text{Expected peso spot rate}}{\text{Current peso spot rate}}$

Of course, this assumes that traders don't care about risk. If they do care, the forward rate can be either higher or lower than the expected spot rate. For example, suppose that you have contracted to receive one million pesos in three months. You can wait until you receive the money before you change it into dollars, but this leaves you open to the risk that the price of the peso may fall over the next three months. Your alternative is to sell the peso forward. In this case, you are fixing today the price at which you will sell your pesos. Since you avoid risk by selling forward, you may be willing to do so even if the forward price of pesos is a little *lower* than the expected spot price.

Other companies may be in the opposite position. They may have contracted to pay out pesos in three months. They can wait until the end of the three months and then buy pesos, but this leaves them open to the risk that the price of the peso may rise. It is safer for these companies to fix the price today by *buying* pesos forward. These companies may, therefore, be willing to buy forward even if the forward price of the peso is a little *higher* than the expected spot price.

Thus, some companies find it safer to *sell* the peso forward, while others find it safer to *buy* the peso forward. When the first group predominates, the forward price of pesos is likely to be less than the expected spot price. When the second group predominates, the forward price is likely to be greater than the expected spot price. On average you would expect the forward price to underestimate the expected spot price just about as often as it overestimates it.

Changes in the Exchange Rate and Inflation Rates

Now we come to the third side of our quadrilateral—the relationship between changes in the spot exchange rate and inflation rates. Suppose that you notice that silver can be bought in Ruritania for 1,000 pesos a troy ounce and sold in the United States for \$30.00. You think you may be on to a good thing. You take \$20,000 and exchange it for \$20,000 × RUP50/USD1 = 1,000,000 pesos. That's enough to buy 1,000 ounces of silver. You put this silver on the first plane to the United States, where you sell it for \$30,000. You have made a gross profit of \$10,000. Of course, you have to pay transportation and insurance costs out of this, but there should still be something left over for you.

Money machines don't exist—not for long, anyway. As others notice the disparity between the price of silver in Ruritania and the price in the United States, the price will be forced up in Ruritania and down in the United States until the profit opportunity disappears. Arbitrage ensures that the dollar price of silver is about the same in the two countries. Of course, silver is a standard and easily transportable commodity, but the same forces should act to equalize the domestic and foreign prices of other goods. Those goods that can be bought more cheaply abroad will be imported, and that will force down the price of domestic products. Similarly, those goods that can be bought more cheaply in the United States will be exported, and that will force down the price of the foreign products.

This is often called *purchasing power parity*.[7] Just as the price of goods in Walmart stores must be roughly the same as the price of goods in Target, so the price of goods in Ruritania when converted into dollars must be roughly the same as the price in the United States:

$$\text{Dollar price of goods in the U.S.} = \frac{\text{peso price of goods in Ruritania}}{\text{number of pesos per dollar}}$$

Purchasing power parity implies that any differences in the rates of inflation will be offset by a change in the exchange rate. For example, if prices are rising by 1.0% in the United States and by 11.1% in Ruritania, the number of pesos that you can buy for \$1 must rise by $1.111/1.01 - 1$, or 10%. Therefore purchasing power parity says that to estimate changes in the spot rate of exchange, you need to estimate differences in inflation rates:[8]

Expected difference in inflation rates		Expected change in spot rate
$\dfrac{1 + \text{expected Ruritanian inflation rate}}{1 + \text{expected U.S. inflation rate}}$	equals	$\dfrac{\text{Expected peso spot rate}}{\text{Current peso spot rate}}$

[7]Economists use the term *purchasing power parity* to refer to the notion that the level of prices of goods in general must be the same in the two countries. They tend to use the phrase *law of one price* when they are talking about the price of a single good.

[8]In other words, the *expected* difference in inflation rates equals the *expected* change in the exchange rate. Strictly interpreted, purchasing power parity also implies that the *actual* difference in the inflation rates always equals the *actual* change in the exchange rate.

In our example,

$$\text{Current spot rate} \times \text{expected difference in inflation rates} = \text{expected spot rate}$$

$$50 \times \frac{1.111}{1.010} = 55$$

Interest Rates and Inflation Rates

Now for the fourth leg! Just as water always flows downhill, so capital tends to flow where returns are greatest. But investors are not interested in *nominal* returns; they care about what their money will buy. So, if investors notice that real interest rates are higher in Ruritania than in the United States, they will shift their savings into Ruritania until the expected real returns are the same in the two countries. If the expected real interest rates are equal, then the difference in nominal interest rates must be equal to the difference in the expected inflation rates:[9]

Difference in interest rates		Expected difference in inflation rates
$\dfrac{1 + \text{Ruritanian interest rate}}{1 + \text{U.S. interest rate}}$	equals	$\dfrac{1 + \text{expected Ruritanian inflation rate}}{1 + \text{expected U.S. inflation rate}}$

In Ruritania the real one-year interest rate is 4%:

$$\text{Ruritanian expected real interest rate} = \frac{1 + \text{Ruritanian nominal interest rate}}{1 + \text{Ruritanian expected inflation rate}} - 1$$

$$= \frac{1.155}{1.111} - 1 = .040$$

In the United States it is also 4%:

$$\text{U.S. expected real interest rate} = \frac{1 + \text{U.S. nominal interest rate}}{1 + \text{U.S. expected inflation rate}} - 1$$

$$= \frac{1.050}{1.010} - 1 = .040$$

Is Life Really That Simple?

We have described four theories that link interest rates, forward rates, spot exchange rates, and inflation rates. Of course, such simple economic theories are not going to provide an exact description of reality. We need to know how well they predict actual behavior. Let's check.

1. Interest Rate Parity Theory Interest rate parity theory says that the peso rate of interest covered for exchange risk should be the same as the dollar rate. Before the financial crisis of 2007–2009, interest rate parity almost always held, provided money could be moved easily between deposits in the different currencies. In fact, dealers would *set* the forward price of pesos by looking at the difference between the interest rates on deposits of dollars and pesos. However, during the financial crisis this relationship broke down. Du, Tepper and Verdahlan provide evidence that the relationship was persistently violated for some time following 2009 among

[9]In Section 3-5, we discussed Irving Fisher's theory that money interest rates change to reflect changes in anticipated inflation. Here we argue that international differences in money interest rates also reflect differences in anticipated inflation. This theory is sometimes known as the *international Fisher effect.*

the major currencies. They argue that this persistence was partly due to new leverage restrictions on banks, which increased arbitrage costs and caused them to shy away from such activity.[10]

2. The Expectations Theory of Forward Rates How well does the expectations theory explain the level of forward rates? Scholars who have studied exchange rates have found that forward rates typically exaggerate the likely change in the spot rate. When the forward rate appears to predict a sharp rise in the spot rate (a forward premium), the forward rate tends to overestimate the rise in the spot rate. Conversely, when the forward rate appears to predict a fall in the currency (a forward discount), it tends to overestimate this fall.[11]

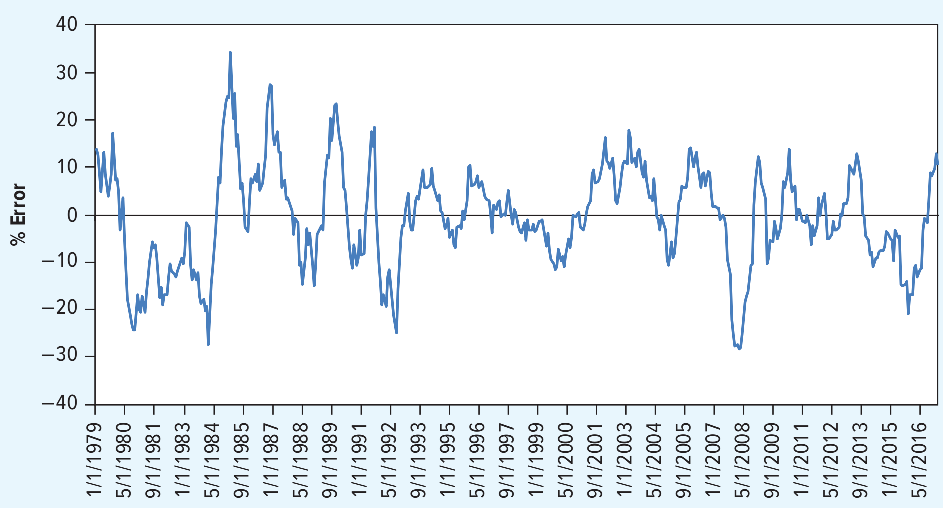
This finding is *not* consistent with the expectations theory. Instead it looks as if sometimes companies are prepared to give up return to *buy* forward currency and other times they are prepared to give up return to *sell* forward currency. In other words, forward rates seem to contain a risk premium, but the sign of this premium swings backward and forward.[12] You can see this from Figure 27.1. Almost half the time the forward rate for the U.K. pound *overstates* the likely future spot rate and half the time it *understates* the likely spot rate. *On average,* the forward rate and future spot rate are almost identical. This is important news for the financial manager; it means that a company that always uses the forward market to protect against exchange rate movements does not pay any extra for this insurance.

That's the good news. The bad news is that the forward rate is a fairly awful forecaster of the spot rate. For example, in Figure 27.1 the large error in 1985 reflects the total failure of the forward rate to anticipate the 34% rise in the value of sterling.

3. Purchasing Power Parity Theory What about the third side of our quadrilateral—purchasing power parity theory? No one who has compared prices in foreign stores with

FIGURE 27.1 Percentage error from using the one-year forward rate for U.K. pounds to forecast next year's spot rate. Note that the forward rate overestimates and underestimates the spot rate with about equal frequency.

Source: Bank of England.



[10]See W. Du, A. Tepper, and A. Verdelhan, "Deviations from Covered Interest Rate Parity," *Journal of Finance,* 73 (February 2018), pp.915–957. However, for evidence that deviations from interest rate parity theory are fading away, see H. Mance, "Cross-Currency Basis, RIP?" FT Alphaville, October 11, 2017, **https://ftalphaville.ft.com/2017/10/11/2194672/cross-currency-basis-rip/**

[11]Many researchers have even found that, when the forward rate predicts a rise, the spot rate is more likely to fall, and vice versa. For a readable discussion of this puzzling finding, see K. A. Froot and R. H. Thaler, "Anomalies: Foreign Exchange," *Journal of Economic Perspectives* 4 (1990), pp. 179–192.

[12]For evidence that forward exchange rates contain risk premiums that are sometimes positive and sometimes negative, see, for example, E. F. Fama, "Forward and Spot Exchange Rates," *Journal of Monetary Economics* 14 (1984), pp. 319–338.

Country	Local Price Converted to U.S. Dollars ($)
Brazil	5.11
Canada	5.26
China	3.17
Egypt	1.93
Euro area	4.84
India	2.82
Japan	3.43
Norway	6.24
Russia	2.29
South Africa	2.45
Switzerland	6.76
Turkey	2.83
United Kingdom	4.41
United States	5.28

TABLE 27.2 Price of Big Mac hamburgers in different countries

Source: "The Mac Strikes Back," *The Economist,* January 20, 2018, http://www.economist.com/content/big-mac-index.

prices at home really believes that prices are the same throughout the world. Look, for example, at Table 27.2, which shows the price of a Big Mac in different countries. Notice that at current rates of exchange a Big Mac costs $6.76 in Switzerland but only $5.28 in the United States. To equalize prices in the two countries, the number of Swiss francs that you could buy for your dollar would need to increase by 6.76/5.28 − 1 = .28, or 28%.

This suggests a possible way to make a quick buck. Why don't you buy a hamburger to-go in (say) Egypt for the equivalent of $1.93 and take it for resale in Switzerland, where the price in dollars is $6.76? The answer, of course, is that the gain would not cover the costs. The same good can be sold for different prices in different countries because transportation is costly and inconvenient.[13]

On the other hand, there is clearly some relationship between inflation and changes in exchange rates. For example, between 2012 and 2017 prices in Malawi rose by 270% relative to prices in the United States. Or, to put it another way, you could say that the relative purchasing power of money in Malawi declined by almost two-thirds. If exchange rates had not adjusted, exporters in Malawi would have found it impossible to sell their goods. But, of course, exchange rates did adjust. In fact, the value of the Malawian kwacha fell by 78% relative to the U.S. dollar.

In Figure 27.2, we have plotted the relative change in purchasing power for a sample of countries against the change in the exchange rate. Malawi is tucked in the bottom left-hand corner. You can see that although the relationship is far from exact, large differences in inflation rates are generally accompanied by an offsetting change in the exchange rate.[14]

Strictly speaking, purchasing power parity theory implies that the differential inflation rate is always identical to the change in the spot rate. But we don't need to go as far as that. We

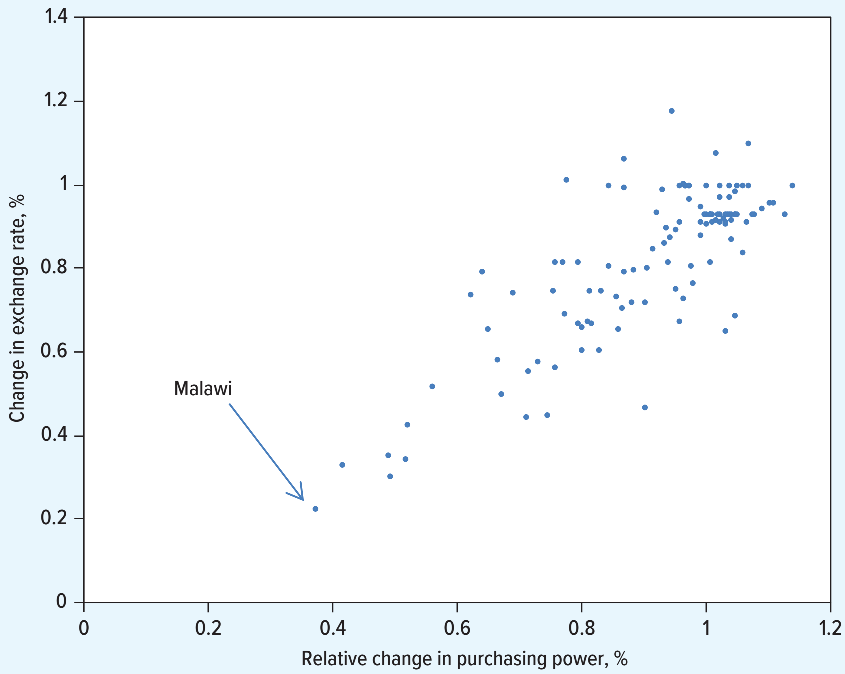
[13]Of course, even within a currency area there may be considerable price variations. The price of a Big Mac, for example, differs substantially from one part of the United States to another.

[14]Note that some of the countries represented in Figure 27.2 have highly controlled economies, so that their exchange rates are not those that would exist in an unrestricted market. The interest rates shown in Figure 27.4 are subject to a similar caveat.

FIGURE 27.2

A decline in the exchange rate and a decline in a currency's purchasing power tend to go hand in hand. In this diagram each of the 120 points represents the experience of a different country in the period 2012–2017. The vertical axis shows the change in the value of the foreign currency relative to the dollar. The horizontal axis shows the change in the purchasing power relative to that of the USA. The point in the lower left is Malawi.

Source: IMF, International Financial Statistics.



should be content if the *expected* difference in the inflation rates equals the *expected* change in the spot rate. That's all we wrote on the third side of our quadrilateral. Look, for example, at Figure 27.3. The blue line in the first plot shows that in 2014 £1 sterling bought only 32% of the dollars that it did at the start of the twentieth century. But this decline in the value of sterling was largely matched by the higher inflation rate in the U.K. The red line shows that the inflation-adjusted, or *real,* exchange rate ended the century at roughly the same level as it began.[15] The second and third plots show the experiences of France and Italy, respectively. The fall in nominal exchange rates for both countries is much greater. Adjusting for changes in currency units, the equivalent of one French franc in 2014 bought about 1% of the dollars that it did at the start of 1900. The equivalent of one Italian lira bought about .4% of the number of dollars. In both cases the real exchange rates in 2014 are not much different from those at the beginning of the twentieth century. Of course, real exchange rates do change, sometimes quite sharply. For example, the real value of sterling fell by 13% in two weeks following the Brexit vote in 2017. However, if you were a financial manager called on to make a long-term forecast of the exchange rate, you could not have done much better than to assume that changes in the value of the currency would offset the difference in inflation rates.

4. Equal Real Interest Rates Finally we come to the relationship between interest rates in different countries. Do we have a single world capital market with the same *real* rate of interest in all countries? Does the difference in money interest rates equal the difference in the expected inflation rates?

[15]The real exchange rate is equal to the nominal exchange rate multiplied by the inflation differential. For example, suppose that the value of sterling falls from $1.65 = £1 to $1.50 = £1 at the same time that the price of goods rises 10% faster in the United Kingdom than in the United States. The inflation-adjusted, or real, exchange rate is unchanged at

$$\text{Nominal exchange rate} \times (1 + i_{£})/(1 + i_{\$}) = 1.50 \times 1.1 = \$1.65/£$$

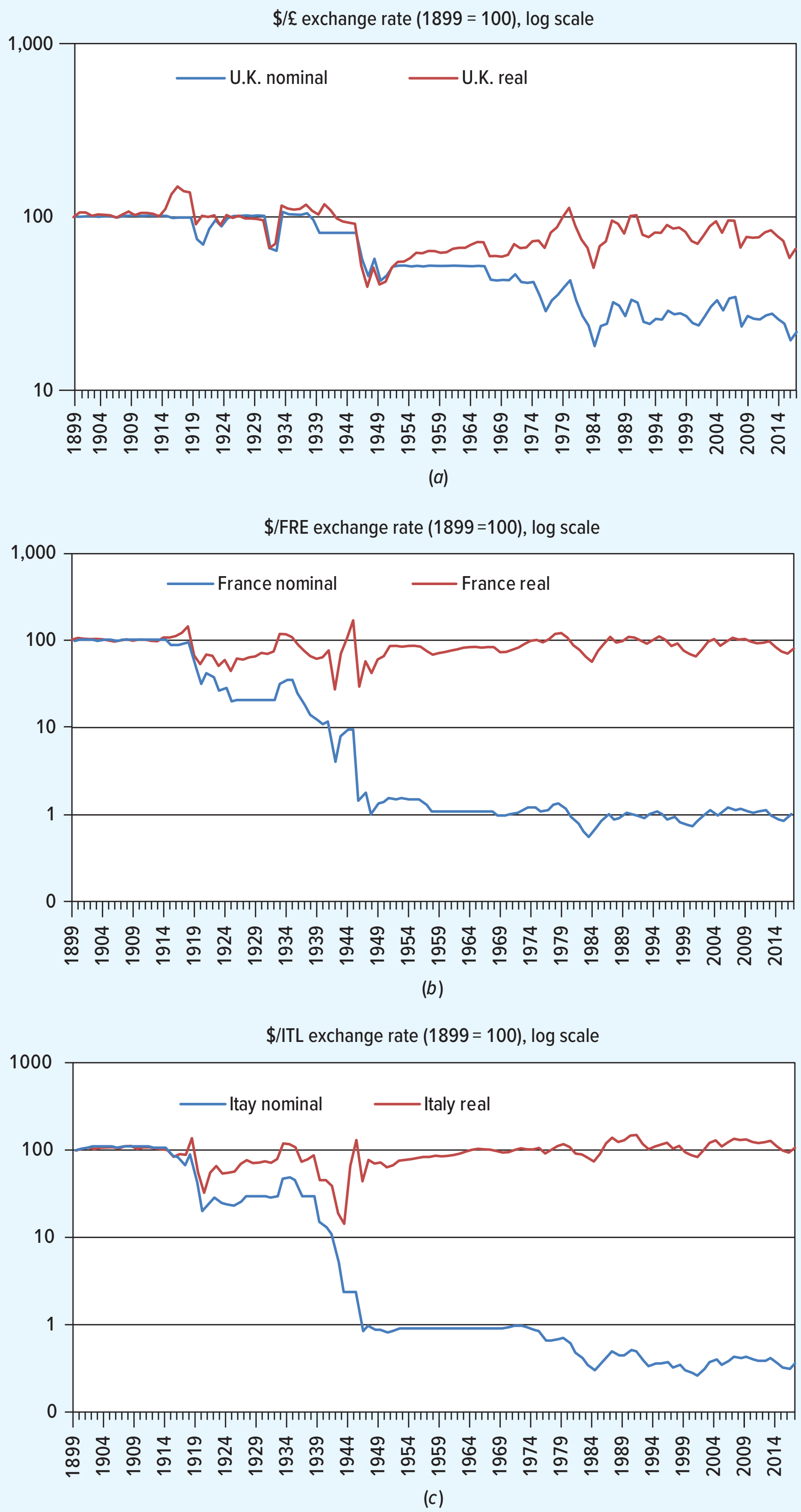


FIGURE 27.3

Nominal versus real exchange rates in the U.K., France, and Italy. December 1899 = 100. (Values are shown on log scale.)

Source: E. Dimson, P. R. Marsh, and M. Staunton, *Triumph of the Optimist: 101 Years of Global Investment Returns* (Princeton, NJ: Princeton University Press, 2002), with updates provided by the authors.

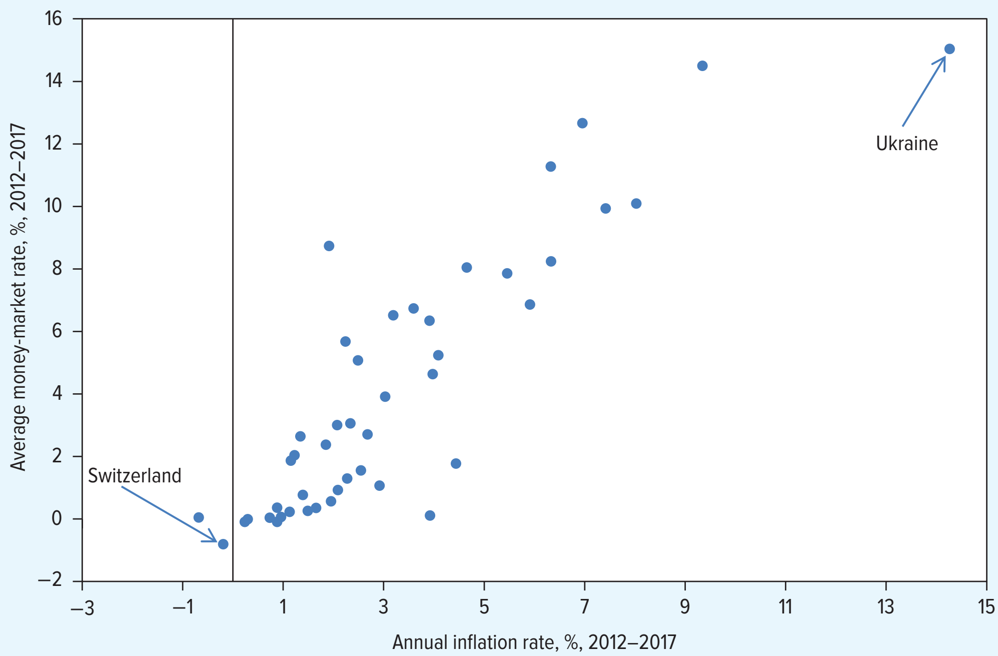


FIGURE 27.4

Countries with the highest interest rates generally have the highest inflation. In this diagram each of the 45 points represents the experience of a different country.

Source: IMF, International Financial Statistics.

This is not an easy question to answer since we cannot observe *expected* inflation. However, in Figure 27.4, we have plotted the average interest rate in each of 45 countries against the average inflation rate. Switzerland is tucked into the bottom-left corner of the chart, while Ukraine is represented by the dot in the top-right corner. You can see that, in general, the countries with the highest interest rates also had the highest inflation rates. There were much smaller differences between the real rates of interest than between the nominal (or money) rates.

This may be a good point at which to offer a warning: Do not naively borrow in currencies with the lowest interest rates. Those low interest rates may reflect the fact that investors expect inflation to be low and the currency to appreciate. In this case, the gain that you realize from "cheap" borrowing is liable to be offset by the high cost of the currency that is needed to service the loan. Many have learned this lesson the hard way. For example, in recent years over 500,000 Poles were lured by low Swiss interest rates into taking out mortgages in Swiss francs. When the Swiss franc jumped by 23% against the Polish zloty in January 2015, many of those borrowers found themselves in big trouble.

Professional foreign exchange traders may, from time to time, enter into *carry trades* in which they take on currency risk by borrowing in countries with low interest rates and then use the cash to buy bonds in countries with high interest rates. But wise corporate managers do not speculate in this way; they use foreign currency loans to offset the effect that exchange rate fluctuations have on the company's business.

27-3 Hedging Currency Risk

Sharp exchange rate movements can make a large dent in corporate profits. To illustrate how companies cope with this problem, we look at a typical company in the United States, Outland Steel, and walk through its foreign exchange operations.

EXAMPLE 27.1 • Outland Steel

Outland Steel has a small but profitable export business. Contracts involve substantial delays in payment, but since the company has a policy of always invoicing in dollars, it is fully protected against changes in exchange rates. Recently, the export department has become unhappy with this practice and believes that it is causing the company to lose valuable export orders to firms that are willing to quote in the customer's own currency.

You sympathize with these arguments, but you are worried about how the firm should price long-term export contracts when payment is to be made in foreign currency. If the value of that currency declines before payment is made, the company may suffer a large loss. You want to take the currency risk into account, but you also want to give the sales force as much freedom of action as possible.

Notice that Outland can insure against its currency risk by selling the foreign currency forward. This means that it can separate the problem of negotiating sales contracts from that of managing the company's foreign exchange exposure. The sales force can allow for currency risk by pricing on the basis of the forward exchange rate. And you, as financial manager, can decide whether the company *ought* to hedge.

What is the cost of hedging? You sometimes hear managers say that it is equal to the difference between the forward rate and *today's* spot rate. That is wrong. If Outland does not hedge, it will receive the spot rate at the time that the customer pays for the steel. Therefore, the cost of insurance is the difference between the forward rate and the expected spot rate when payment is received.

Insure or speculate? We generally vote for insurance. First, it makes life simpler for the firm and allows it to concentrate on its main business. Second, it does not cost much. (In fact, the cost is zero on average if the forward rate equals the expected spot rate, as the expectations theory of forward rates implies.) Third, the foreign currency market seems reasonably efficient, at least for the major currencies. Speculation should be a zero-NPV game, unless financial managers have information that is not available to the pros who make the market.

Is there any other way that Outland can protect itself against exchange loss? Of course. It can borrow foreign currency against its foreign receivables, sell the currency spot, and invest the proceeds in the United States. Interest rate parity theory tells us that in free markets the difference between selling forward and selling spot should be equal to the difference between the interest that you have to pay overseas and the interest that you can earn at home.

Our discussion of Outland's export business illustrates four practical implications of our simple theories about forward exchange rates. First, you can use forward rates to adjust for exchange risk in contract pricing. Second, the expectations theory suggests that protection against exchange risk is usually worth having. Third, interest rate parity theory reminds us that you can hedge either by selling forward or by borrowing foreign currency and selling spot. Fourth, the cost of forward cover is not the difference between the forward rate and *today's* spot rate; it is the difference between the forward rate and the expected spot rate when the forward contract matures.

Perhaps we should add a fifth implication. You don't make money simply by buying currencies that go up in value and selling those that go down. For example, suppose that you buy Narnian leos and sell them after a year for 2% more than you paid for them. Should you give yourself a pat on the back? That depends on the interest that you have earned on your leos. If the interest rate on leos is 2 percentage points less than the interest rate on dollars, the profit on the currency is exactly canceled out by the reduction in interest income. Thus you make money from currency speculation only if you can predict whether the exchange rate will change by more or less than the interest rate differential. In other words, you must be able to predict whether the exchange rate will change by more or less than the forward premium or discount.

Transaction Exposure and Economic Exposure

BEYOND THE PAGE Operational hedging by auto producers mhhe.com/brealey13e

The exchange risk from Outland Steel's export business is due to delays in foreign currency payments and is therefore referred to as *transaction exposure*. Transaction exposure can be easily identified and hedged. Consider, for example, its exports to Europe. Since a 1% fall in the value of the euro results in a 1% fall in Outland's dollar receipts, for every euro that Outland is owed by its customers, it needs to sell forward one euro.[16]

However, Outland may still be affected by currency fluctuations even if its customers do not owe it a cent. For example, Outland may be in competition with Swedish steel producers. If the value of the Swedish krona falls, Outland will need to cut its prices in order to compete.[17] Outland can protect itself against such an eventuality by selling the krona forward. In this case the loss on Outland's steel business will be offset by the profit on its forward sale.

Notice that Outland's exposure to the krona is not limited to specific transactions that have already been entered into. Financial managers often refer to this broader type of exposure as *economic exposure*.[18] Economic exposure is less easy to measure than transaction exposure. For example, it is clear that the value of Outland Steel is positively related to the value of the krona, so to hedge its position it needs to sell kronor forward. But, in practice, it may be hard to say exactly how many kronor Outland needs to sell.

BEYOND THE PAGE Operational hedging and the Swiss franc mhhe.com/brealey13e

Large Swiss companies, such as Nestlé or the Swatch Group, sell their products around the world. Therefore, like Outland Steel, they need to manage their economic exposure. One solution is to undertake operational hedging by balancing production closely with sales. Look, for example, at Table 27.3, which summarizes the overseas sales and costs for a sample of well-known Swiss companies. Notice that in the case of Nestlé and Swiss Re, sales and costs are almost perfectly matched. These companies are, therefore, relatively immune to fluctuations in the exchange rate. By contrast, in the case of Swatch and Richemont, a substantial

		Swiss Franc		Euro		U.S. Dollar		Other	
Company	Activity	Sales	Costs	Sales	Costs	Sales	Costs	Sales	Costs
Adecco	Employment agency	2	2	48	45	20	19	30	34
Holcim	Cement	4	6	10	10	21	25	65	59
Lindt & Sprüngli	Chocolate	5	12	43	35	40	25	12	28
Nestlé	Food producer	2	5	30	30	30	30	38	35
Novartis	Pharmaceuticals	2	15	26	25	36	40	36	20
Richemont	Luxury goods	5	20	30	20	50	40	15	20
Swatch Group	Luxury goods	10	30	30	20	50	25	10	25
Swiss Re	Insurance	3	5	20	20	40	40	37	35

TABLE 27.3 **The proportion of sales and costs for major Swiss companies that derive from particular currency areas**

Source: UBS.

[16]To put it another way, the hedge ratio is 1.0.

[17]Of course, if purchasing power parity always held, the fall in the value of the krona would be matched by higher inflation in Sweden. The risk for Outland is that the *real* value of the krona may decline so that when measured in dollars, Swedish costs are lower than previously. Unfortunately, it is much easier to hedge against a change in the *nominal* exchange rate than against a change in the *real* rate.

[18]Financial managers also refer to *translation exposure,* which measures the effect of an exchange rate change on the company's financial statements.

proportion of production costs arise in Switzerland, and therefore both companies are exposed to an appreciation of the Swiss franc.

In addition to operational hedging, companies can also control exchange rate risk by using financial hedges. They do this by borrowing in foreign currencies, selling currency forward, or using foreign currency derivatives such as swaps and options. For example, in 2014 Swatch used forwards primarily to reduce its exposure to the euro and dollar. At the end of the year, these forward contracts totaled nearly 1.5 billion Swiss francs.

27-4 Exchange Risk and International Investment Decisions

Suppose that the Swiss pharmaceutical company, Roche, is evaluating a proposal to build a new plant in the United States. To calculate the project's net present value, Roche forecasts the following dollar cash flows from the project:

Cash Flows ($ millions)					
C_0	C_1	C_2	C_3	C_4	C_5
−1,300	400	450	510	575	650

These cash flows are stated in dollars. So to calculate their net present value Roche discounts them at the dollar cost of capital. (Remember dollars need to be discounted at a *dollar* rate, not the Swiss franc rate.) Suppose this cost of capital is 12%. Then

$$\text{NPV} = -1{,}300 + \frac{400}{1.12} + \frac{450}{1.12^2} + \frac{510}{1.12^3} + \frac{575}{1.12^4} + \frac{650}{1.12^5} = \$513 \text{ million}$$

To convert this net present value to Swiss francs, the manager can simply multiply the dollar NPV by the spot rate of exchange. For example, if the spot rate is CHF1.2/$, then the NPV in Swiss francs is

$$\text{NPV in francs} = \text{NPV in dollars} \times \text{CHF/\$} = 513 \times 1.2 = 616 \text{ million francs}$$

Notice one very important feature of this calculation. Roche does not need to forecast whether the dollar is likely to strengthen or weaken against the Swiss franc. No currency forecast is needed because the company can hedge its foreign exchange exposure. In that case, the decision to accept or reject the pharmaceutical project in the United States is totally separate from the decision to bet on the outlook for the dollar. For example, it would be foolish for Roche to accept a poor project in the United States just because management is optimistic about the outlook for the dollar; if Roche wishes to speculate in this way it can simply buy dollars forward. Equally, it would be foolish for Roche to reject a good project just because management is pessimistic about the dollar. The company would do much better to go ahead with the project and sell dollars forward. In that way, it would get the best of both worlds.[19]

When Roche ignores currency risk and discounts the dollar cash flows at a dollar cost of capital, it is implicitly assuming that the currency risk is hedged. Let us check this by calculating the number of Swiss francs that Roche would receive if it hedged the currency risk by selling forward each future dollar cash flow.

[19]There is a general point here that is not confined to currency hedging. Whenever you face an investment that appears to have a positive NPV, decide what it is that you are betting on and then think whether there is a more direct way to place the bet. For example, if a copper mine looks profitable only because you are unusually optimistic about the price of copper, then maybe you would do better to buy copper futures or the shares of other copper producers rather than opening a copper mine.

We need first to calculate the forward rate of exchange between dollars and francs. This depends on the interest rates in the United States and Switzerland. For example, suppose that the dollar interest rate is 6% and the Swiss franc interest rate is 4%. Then interest rate parity theory tells us that the one-year forward exchange rate is

$$s_{\mathrm{CHF/\$}} \times (1 + r_{\mathrm{CHF}})/(1 + r_{\$}) = \frac{1.2 \times 1.04}{1.06} = 1.177$$

Similarly, the two-year forward rate is

$$s_{\mathrm{CHF/\$}} \times (1 + r_{\mathrm{CHF}})^2/(1 + r_{\$})^2 = \frac{1.2 \times 1.04^2}{1.06^2} = 1.155$$

So, if Roche hedges its cash flows against exchange rate risk, the number of Swiss francs it will receive in each year is equal to the dollar cash flow times the forward rate of exchange:

Cash Flows (millions of Swiss francs)					
C_0	C_1	C_2	C_3	C_4	C_5
−1,300 × 1.2 = −1,560	400 × 1.177 = 471	450 × 1.155 = 520	510 × 1.133 = 578	575 × 1.112 = 639	650 × 1.091 = 709

These cash flows are in Swiss francs and therefore they need to be discounted at the risk-adjusted Swiss franc discount rate. Since the Swiss rate of interest is lower than the dollar rate, the risk-adjusted discount rate must also be correspondingly lower. The formula for converting from the required dollar return to the required Swiss franc return is[20]

$$(1 + \text{Swiss franc return}) = (1 + \text{dollar return}) \times \frac{(1 + \text{Swiss franc interest rate})}{(1 + \text{dollar interest rate})}$$

In our example,

$$(1 + \text{Swiss franc return}) = 1.12 \times \frac{1.04}{1.06} = 1.099$$

Thus the risk-adjusted discount rate in dollars is 12%, but the discount rate in Swiss francs is only 9.9%.

All that remains is to discount the Swiss franc cash flows at the 9.9% risk-adjusted discount rate:

$$\begin{aligned} \text{NPV} &= -1{,}560 + \frac{471}{1.099} + \frac{520}{1.099^2} + \frac{578}{1.099^3} + \frac{639}{1.099^4} + \frac{709}{1.099^5} \\ &= 616 \text{ million francs} \end{aligned}$$

Everything checks. We obtain exactly the same net present value by (1) ignoring currency risk and discounting Roche's dollar cash flows at the dollar cost of capital and (2) calculating the cash flows in francs on the assumption that Roche hedges the currency risk and then discounting these Swiss franc cash flows at the franc cost of capital.

[20]The following example should give you a feel for the idea behind this formula. Suppose the spot rate for Swiss francs is CHF 1.2 = \$1. Interest rate parity tells us that the forward rate must be 1.2 × 1.04/1.06 = CHF 1.177/\$. Now suppose that a share costs \$100 and will pay an expected \$112 at the end of the year. The cost to Swiss investors of buying the share is 100 × 1.2 = CHF 120. If the Swiss investors sell forward the expected payoff, they will receive an expected 112 × 1.177 = CHF 131.9. The expected return in Swiss francs is 131.9/120 − 1 = .099, or 9.9%. More simply, the Swiss franc return is 1.12 × 1.04/1.06 − 1 = .099.

To repeat: When deciding whether to invest overseas, separate out the investment decision from the decision to take on currency risk. This means that your views about future exchange rates should NOT enter into the investment decision. The simplest way to calculate the NPV of an overseas investment is to forecast the cash flows in the foreign currency and discount them at the foreign currency cost of capital. The alternative is to calculate the cash flows that you would receive if you hedged the foreign currency risk. In this case, you need to translate the foreign currency cash flows into your own currency *using the forward exchange rate* and then discount these domestic currency cash flows at the domestic cost of capital. If the two methods don't give the same answer, you have made a mistake.

When Roche analyzes the proposal to build a plant in the United States, it is able to ignore the outlook for the dollar *only because it is free to hedge the currency risk*. Because investment in a pharmaceutical plant does not come packaged with an investment in the dollar, the opportunity for firms to hedge allows for better investment decisions.

The Cost of Capital for International Investments

Roche should discount dollar cash flows at a dollar cost of capital. But how should a Swiss company like Roche calculate a cost of capital in dollars for an investment in the United States? There is no simple, consensus procedure for answering this question, but we suggest the following procedure as a start.

First you need to decide on the risk of a U.S. pharmaceutical investment to a Swiss investor. You could look at the betas of a sample of U.S. pharmaceutical companies *relative to the Swiss market index.*

Why measure betas relative to the Swiss index, while a U.S. counterpart such as Merck would measure betas relative to the U.S. index? The answer lies in Section 7-4, where we explained that risk cannot be considered in isolation; it depends on the other securities in the investor's portfolio. Beta measures risk *relative to the investor's portfolio.* If U.S. investors already hold the U.S. market, an additional dollar invested at home is just more of the same. But if Swiss investors hold the Swiss market, an investment in the United States can reduce their risk because the Swiss and U.S. markets are not perfectly correlated. That explains why an investment in the United States can be lower risk for Roche's shareholders than for Merck's shareholders. It also explains why Roche's shareholders may be willing to accept a relatively low expected return from a U.S. investment.[21]

Suppose that you decide that the investment's beta relative to the Swiss market is .8 and that the market risk premium in Switzerland is 7.4%. Then the required return on the project can be estimated as

$$\begin{aligned}\text{Required return} &= \text{Swiss interest rate} + (\text{beta} \times \text{Swiss market risk premium})\\ &= 4 + (.8 \times 7.4) = 9.9\end{aligned}$$

This is the project's cost of capital measured in Swiss francs. We used it to discount the expected *Swiss franc* cash flows if Roche hedged the project against currency risk. We cannot use it to discount the *dollar* cash flows from the project.

To discount the expected *dollar* cash flows, we need to convert the Swiss franc cost of capital to a dollar cost of capital. This means running our earlier calculation in reverse:

$$(1 + \text{dollar return}) = (1 + \text{Swiss franc return}) \times \frac{(1 + \text{dollar interest rate})}{(1 + \text{Swiss franc interest rate})}$$

[21]When an investor holds an efficient portfolio, the expected reward for risk on each stock in the portfolio is proportional to its beta *relative to the portfolio.* So if the Swiss market index is an efficient portfolio for Swiss investors, then these investors will want Roche to invest in the United States if the expected rate of return more than compensates for the investment's beta relative to the Swiss index.

In our example,

$$(1 + \text{dollar return}) = 1.099 \times \frac{1.06}{1.04} = 1.12$$

We used this 12% dollar cost of capital to discount the forecasted dollar cash flows from the project.

When a company measures risk relative to its domestic market as in our example, its managers are implicitly assuming that shareholders hold simply domestic stocks. That is not a bad approximation, particularly in the United States. Although U.S. investors can reduce their risk by holding an internationally diversified portfolio of shares, they generally invest only a small proportion of their money overseas. Why they are so shy is a puzzle. It looks as if they are worried about the costs of investing overseas, such as the extra costs involved in identifying which stocks to buy, or the possibility of unfair treatment by foreign companies or governments.

The world is getting smaller and "flatter," however, and investors everywhere are increasing their holdings of foreign securities. Pension funds and other institutional investors have diversified internationally, and dozens of mutual funds have been set up for people who want to invest abroad. If investors throughout the world held the world portfolio, then costs of capital would converge. The cost of capital would still depend on the risk of the investment, but not on the domicile of the investing company. There is some evidence that for large U.S. firms it does not make much difference whether a U.S. or global beta is used. For firms in smaller countries, the evidence is not so clear-cut and sometimes a global beta may be more appropriate.[22]

27-5 Political Risk

So far, we have focused on the management of exchange rate risk, but managers also worry about political risk. By this they mean the threat that a government will change the rules of the game—that is, break a promise or understanding—*after* the investment is made. Of course political risks are not confined to overseas investments. Businesses in every country are exposed to the risk of unanticipated actions by governments or the courts. But in some parts of the world foreign companies are particularly vulnerable.

A number of consultancy services offer analyses of political and economic risks and draw up country rankings.[23] For example, Table 27.4 is an extract from the 2016 political risk rankings provided by the PRS Group. Each country is scored on 15 separate dimensions. You can see that Norway comes top of the class overall, while Syria languishes at the bottom.

Some managers dismiss political risk as an act of God, like a hurricane or earthquake. But the most successful multinational companies structure their business to reduce political risk. Foreign governments are not likely to expropriate a local business if it cannot operate without the support of its parent. For example, the foreign subsidiaries of American computer manufacturers or pharmaceutical companies would have relatively little value if they were cut off from the know-how of their parents. Such operations are much less likely to be expropriated than, say, a mining operation that can be operated as a stand-alone venture.

We are not recommending that you turn your silver mine into a pharmaceutical company, but you may be able to plan your overseas manufacturing operations to improve your

[22]See R. M. Stulz, "The Cost of Capital in Internationally Integrated Markets: The Case of Nestlé," *European Financial Management* 1, no. 1 (1995), pp. 11–22; R. S. Harris, F. C. Marston, D. R. Mishra, and T. J. O'Brien, "Ex Ante Cost of Equity Estimates of S&P 500 Firms: The Choice between Global and Domestic CAPM," *Financial Management* 32 (Autumn 2003), pp. 51–66; and Standard & Poor's, "Domestic vs. Global CAPM," *Global Cost of Capital Report,* 4th Quarter 2003.

[23]For a discussion of these services see C. Erb, C. R. Harvey, and T. Viskanta, "Political Risk, Economic Risk, and Financial," *Financial Analysts Journal* 52 (1996), pp. 29–46. Also, Campbell Harvey's webpage (**http://people.duke.edu/~charvey/**) is a useful source of information on political risk.

Maximum Score 100		
Country	**Total Score**	**Rank**
Norway	88.3	1
Switzerland	88.0	2
Singapore	87.3	3
Sweden	85.8	5
Germany	84.3	6
Japan	82.5	9
Canada	81.0	15=
Korea, Republic	81.0	15=
United Kingdom	79.8	18
United States	79.3	19
Australia	78.0	23=
Italy	75.3	34
France	73.5	43=
China	71.3	55=
India	69.8	63=
Greece	68.5	70=
Argentina	64.5	85
Brazil	63.3	97=
Russia	62.5	103
Turkey	62.3	107=
Venezuela	48.3	137=
Syria	37.0	140

Note: = denotes a tie

TABLE 27.4 **Political risk scores for a sample of countries, 2016**

Source: *International Country Risk Guide,* a publication of The PRS Group, Inc. **(www.prsgroup.com)**, 2016.

bargaining position with foreign governments. For example, Ford has integrated its overseas operations so that the manufacture of components, subassemblies, and complete automobiles is spread across plants in a number of countries. None of these plants would have much value on its own, and Ford can switch production between plants if the political climate in one country deteriorates.

Multinational corporations have also devised financing arrangements to help keep foreign governments honest. For example, suppose your firm is contemplating an investment of $500 million to reopen the San Tomé silver mine in Costaguana with modern machinery, smelting equipment, and shipping facilities.[24] The Costaguanan government agrees to invest in roads and other infrastructure and to take 20% of the silver produced by the mine in lieu of taxes. The agreement is to run for 25 years.

The project's NPV on these assumptions is quite attractive. But what happens if a new government comes into power five years from now and imposes a 50% tax on "any precious metals exported from the Republic of Costaguana"? Or changes the government's share of output from 20% to 50%? Or simply takes over the mine "with fair compensation to be determined in due course by the Minister of Natural Resources of the Republic of Costaguana"?

[24]The early history of the San Tomé mine is described in Joseph Conrad's *Nostromo*.

No contract can absolutely restrain sovereign power. But you can arrange project financing to make these acts as painful as possible for the foreign government. For example, you might set up the mine as a subsidiary corporation, which then borrows a large fraction of the required investment from a consortium of major international banks. If your firm guarantees the loan, make sure the guarantee stands only if the Costaguanan government honors its contract. The government will be reluctant to break the contract if that causes a default on the loans and undercuts the country's credit standing with the international banking system.

If possible, you should arrange for the World Bank (or one of its affiliates) to finance part of the project or to guarantee your loans against political risk.[25] Few governments have the guts to take on the World Bank. Here is another variation on the same theme. Arrange to borrow, say, $450 million through the Costaguanan Development Agency. In other words, the development agency borrows in international capital markets and relends to the San Tomé mine. Your firm agrees to stand behind the loan as long as the government keeps its promises. If it does keep them, the loan is your liability. If not, the loan is *its* liability.

Political risk is not confined to the risk of expropriation. Multinational companies are always exposed to the criticism that they siphon funds out of countries in which they do business, and, therefore, governments are tempted to limit their freedom to repatriate profits. This is most likely to happen when there is considerable uncertainty about the rate of exchange, which is usually when you would most like to get your money out. Here, again, a little forethought can help. For example, there are often more onerous restrictions on the payment of dividends to the parent than on the payment of interest or principal on debt. Royalty payments and management fees are less sensitive than dividends, particularly if they are levied equally on all foreign operations.

Calculating NPVs for investment projects becomes exceptionally difficult when political risks are significant. You have to estimate cash flows and project life with extra caution. You may want to take a peek at the discounted payback period (see Chapter 5), on the theory that quick-payback projects are less exposed to political risks. But do not try to compensate for political risks by adding casual fudge factors to discount rates. Fudge factors spawn bias and confusion, as we explained in Chapter 9.

[25] In the appendix to Chapter 24, we described how the backing of the World Bank helped to arrange financing for the Central Java power project.

SUMMARY

The international financial manager has to cope with different currencies, interest rates, and inflation rates. To produce order out of chaos, the manager needs some model of how they are related. We described four very simple but useful theories.

Interest rate parity theory states that the interest differential between two countries must be equal to the difference between the forward and spot exchange rates. In the international markets, arbitrage ensures that parity generally holds. There are two ways to hedge against exchange risk: One is to take out forward cover; the other is to borrow or lend abroad. Interest rate parity tells us that the costs of the two methods should be the same.

The expectations theory of exchange rates tells us that the forward rate equals the expected spot rate. In practice, forward rates seem to incorporate a risk premium, but this premium is about equally likely to be negative as positive.

In its strict form, purchasing power parity states that $1 must have the same purchasing power in every country. That doesn't square well with the facts because differences in inflation rates are not perfectly related to changes in exchange rates. This means that there may be some genuine exchange risks in doing business overseas. On the other hand, a financial manager, who needs to make a long-term forecast of the exchange rate, cannot do much better than to assume that the real exchange rate will not change.

Finally, we saw that in an integrated world capital market real rates of interest would have to be the same. In practice, government regulation and taxes can cause differences in real interest rates. But do not simply borrow where interest rates are lowest. Those countries are also likely to have the lowest inflation rates and the strongest currencies.

With these precepts in mind, we showed how you can use forward markets or the loan markets to hedge transactions exposure, which arises from delays in foreign currency payments and receipts. But the company's financing choices also need to reflect the impact of a change in the exchange rate on the value of the entire business. This is known as economic exposure. Companies protect themselves against economic exposure either by hedging in the financial markets or by building plants overseas.

Because companies can hedge their currency risk, the decision to invest overseas does not involve currency forecasts. There are two ways for a company to calculate the NPV of an overseas project. The first is to forecast the foreign currency cash flows and to discount them at the foreign currency cost of capital. The second is to translate the foreign currency cash flows into domestic currency assuming that they are hedged against exchange rate risk. These domestic currency flows can then be discounted at the domestic cost of capital. The answers should be identical.

In addition to currency risk, overseas operations may be exposed to extra political risk. However, firms may be able to structure the financing to reduce the chances that government will change the rules of the game.

FURTHER READING

There are a number of useful textbooks in international finance. Here is a small selection:

P. Sercu, *International Finance: Theory into Practice* (Princeton, NJ: Princeton University Press, 2009).

D. K. Eiteman, A. I. Stonehill, and M. H. Moffett, *Multinational Business Finance,* 13th ed. (Cambridge, England: Pearson, 2012).

A. C. Shapiro, *Multinational Financial Management,* 10th ed. (New York: John Wiley & Sons, 2013).

Here are some general discussions of international investment decisions and associated exchange risks:

G. Allayannis, J. Ihrig, and J. P. Weston, "Exchange-Rate Hedging: Financial versus Operational Strategies," *American Economic Review* 91 (May 2001), pp. 391–395.

D. R. Lessard, "Global Competition and Corporate Finance in the 1990s," *Journal of Applied Corporate Finance* 3 (Winter 1991), pp. 59–72.

M. D. Levi and P. Sercu, "Erroneous and Valid Reasons for Hedging Foreign Exchange Rate Exposure," *Journal of Multinational Finance Management* 1 (1991), pp. 25–37.

Listed below are a few of the articles on the relationship between interest rates, exchange rates, and inflation:

Forward and spot exchange rates

M. D. Evans and K. K. Lewis, "Do Long-Term Swings in the Dollar Affect Estimates of the Risk Premia?" *Review of Financial Studies* 8 (1995), pp. 709–742.

Interest rate parity

K. Clinton, "Transactions Costs and Covered Interest Arbitrage: Theory and Evidence," *Journal of Political Economy* 96 (April 1988), pp. 358–370.

Purchasing power parity

K. Froot and K. Rogoff, "Perspectives on PPP and Long-run Real Exchange Rates," in G. Grossman and K. Rogoff (eds.), *Handbook of International Economics* (Amsterdam: North-Holland Publishing Company, 1995).

K. Rogoff, "The Purchasing Power Parity Puzzle," *Journal of Economic Literature* 34 (June 1996), pp. 647–668.

A. M. Taylor and M. P. Taylor, "The Purchasing Power Parity Debate," *Journal of Economic Perspectives* 18 (Autumn 2004), pp. 135–158.

PROBLEM SETS

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

1. **Exchange rates*** Look at Table 27.1.
   a. How many Japanese yen do you get for your dollar?
   b. What is the three-month forward rate for yen?
   c. Is the yen at a forward discount or premium on the dollar?
   d. Use the one-year forward rate to calculate the annual percentage discount or premium on yen.
   e. If the one-year interest rate on dollars is 2.5% annually compounded, what do you think is the one-year interest rate on yen?
   f. According to the expectations theory, what is the expected spot rate for yen in three months' time?
   g. According to purchasing power parity theory, what then is the expected difference in the three-month rate of price inflation in the United States and Japan?
2. **Exchange rates** Table 27.1 shows the 3-month forward rate on the South African rand.
   a. Is the dollar at a forward discount or premium on the rand?
   b. What is the annual *percentage* discount or premium?
   c. If you have no other information about the two currencies, what is your best guess about the spot rate on the rand three months hence?
   d. Suppose that you expect to receive 100,000 rand in three months. How many dollars is this likely to be worth?
3. **Some basic relationships** Define each of the following theories in a sentence or simple equation:
   a. Interest rate parity.
   b. Expectations theory of forward rates.
   c. Purchasing power parity.
   d. International capital market equilibrium (relationship of real and nominal interest rates in different countries).
4. **Interest rate parity** Look again at Table 27.1. Which countries would you expect to have a lower 1-year interest rate than the United States?
5. **Interest rate parity** The following table shows interest rates and exchange rates for the U.S. dollar and the Lilliputian nano. The spot exchange rate is 15 nanos = $1. Complete the missing entries:

	1 Month	3 Months	1 Year
Dollar interest rate (annually compounded)	4.0	4.5	?
Nano interest rate (annually compounded)	8.2	?	9.8
Forward nanos per dollar	?	?	15.6
Forward discount on nano (% per year)	?	4.8	?

TABLE 27.5 Interest rates and exchange rates

	Interest Rate (%)	Spot Exchange Rate[a]	1-Year Forward Exchange Rate[a]
United States (dollar)	3	—	—
Costaguana (pulga)	23	10,000	11,942
Westonia (ruple)	5	2.6	2.65
Gloccamorra (pint)	8	17.1	18.2
Anglosaxophonia (wasp)	4.1	2.3	2.28

[a]Number of units of foreign currency that can be exchanged for $1.

6. **Interest rate parity** Look at Table 27.1. If the three-month interest rate on dollars is 0.2%, what do you think is the three-month interest rate on the Brazilian real? Explain what would happen if the rate were substantially above your figure.
7. **Interest rate parity** Table 27.5 shows the annual interest rate (annually compounded) and exchange rates against the dollar for different currencies. Are there any arbitrage opportunities? If so, how would you secure a positive cash flow today, while zeroing out all future cash flows?
8. **Purchasing power parity** In March 2017, the exchange rate for the Narnian leo was L2,419 = $1. Inflation in the year to March 2018 was about 30% in Narnia and 2% in the United States.
   a. If purchasing power parity held, what should have been the nominal exchange rate in March 2018?
   b. The actual exchange rate in March 2018 in the midst of a currency crisis was L8,325 = $1. What was the change in the *real* exchange rate?
9. **Interest rates and exchange rates** Penny Farthing, the treasurer of International Bicycles Inc. has noticed that the interest rate in Japan is below the rates in most other countries. Therefore, she is suggesting that the company should make an issue of Japanese yen bonds. Does this make sense?
10. **Currency risk** Suppose that in 2023 one- and two-year interest rates are 5.2% in the United States and 1.0% in Japan. The spot exchange rate is ¥120.22/$. Suppose that one year later interest rates are 3% in both countries, while the value of the yen has appreciated to ¥115.00/$.
    a. Benjamin Pinkerton from New York invested in a U.S. two-year zero-coupon bond at the start of the period and sold it after one year. What was his return?
    b. Madame Butterfly from Osaka bought some dollars. She also invested in the two-year U.S. zero-coupon bond and sold it after one year. What was her return in yen?
    c. Suppose that Ms. Butterfly had correctly forecasted the price at which she sold her bond and that she hedged her investment against currency risk. How could she have hedged? What would have been her return in yen?
11. **Currency risk** Companies may be affected by changes in the nominal exchange rate or in the real exchange rate. Explain how this can occur. Which changes are easiest to hedge against?
12. **Currency risk** You have bid for a possible export order that would provide a cash inflow of €1 million in six months. The spot exchange rate is $1.3549 = €1 and the six-month forward rate is $1.3620 = €1. There are two sources of uncertainty: (1) the euro could appreciate or depreciate and (2) you may or may not receive the export order. Illustrate in each case the final payoffs if (a) you sell 1 million euros forward, and (b) you buy a six-month option to sell euros with an exercise price of $1.3620/€.
13. **Currency risk*** In December 2017, an American investor buys 1,000 shares in a Mexican company at a price of 500 pesos each. The share does not pay any dividend. A year later she sells the shares for 550 pesos each. The exchange rates when she buys the stock are shown in Table 27.1. Suppose that the exchange rate at the time of sale is 20 pesos = $1.

a. How many dollars does she invest?
b. What is her total return in pesos? In dollars?
c. Do you think that she has made an exchange rate profit or loss? Explain.

14. **Currency hedging*** An importer in the United States is due to take delivery of clothing from Mexico in six months. The price is fixed in Mexican pesos. Which of the following transactions could eliminate the importer's exchange risk?
   a. Sell six-month call options on pesos.
   b. Buy pesos forward.
   c. Sell pesos forward.
   d. Sell pesos in the currency futures market.
   e. Borrow pesos; buy dollars at the spot exchange rate.
   f. Sell pesos at the spot exchange rate; lend dollars.
15. **Currency hedging** A U.S. company has committed to pay 10 million kronor to a Swedish company in one year. What is the cost (in present value) of covering this liability by buying kronor forward? The Swedish interest rate is .6%, and exchange rates are shown in Table 27.1. Briefly explain.
16. **Currency hedging** A firm in the United States is due to receive payment of €1 million in eight years' time. It would like to protect itself against a decline in the value of the euro, but finds it difficult to get forward cover for such a long period. Is there any other way in which it can protect itself?
17. **Currency hedging** Suppose you are the treasurer of Lufthansa, the German international airline. How is company value likely to be affected by exchange rate changes? What policies would you adopt to reduce exchange rate risk?
18. **Currency hedging** A Ford dealer in the United States may be exposed to a devaluation of the yen if this leads to a cut in the price of Japanese cars. Suppose that the dealer estimates that a 1% decline in the value of the yen would result in a permanent decline of 5% in the dealer's profits. How should she hedge against this risk, and how should she calculate the size of the hedge position? (*Hint:* You may find it helpful to refer to Section 26-6.)
19. **Currency hedging** "Last year we had a substantial income in sterling, which we hedged by selling sterling forward. In the event sterling appreciated. So our decision to sell forward cost us a lot of money. I think that in the future we should either stop hedging our currency exposure or just hedge when we think sterling is overvalued." As financial manager, how would you respond to your chief executive's comment?
20. **Investment decisions** Carpet Baggers Inc. is proposing to construct a new bagging plant in a country in Europe. The two prime candidates are Germany and Switzerland. The forecasted cash flows from the proposed plants are as follows:

	C_0	C_1	C_2	C_3	C_4	C_5	C_6	IRR (%)
Germany (millions of euros)	−60	+10	+15	+15	+20	+20	+20	15.0
Switzerland (millions of Swiss francs)	−120	+20	+30	+30	+35	+35	+35	12.8

The spot exchange rate for euros is $1.3/€, while the rate for Swiss francs is CHF 1.5/$. The interest rate is 5% in the United States, 4% in Switzerland, and 6% in the euro countries. The financial manager has suggested that, if the cash flows were stated in dollars, a return in excess of 10% would be acceptable.

Should the company go ahead with either project? If it must choose between them, which should it take?

21. **Investment decisions*** It is the year 2021 and Pork Barrels Inc. is considering construction of a new barrel plant in Spain. The forecasted cash flows in millions of euros are as follows:

C_0	C_1	C_2	C_3	C_4	C_5
−80	+10	+20	+23	+27	+25

The spot exchange rate is \$1.2 = €1. The interest rate in the United States is 8%, and the euro interest rate is 6%. You can assume that pork barrel production is effectively risk-free.

a. Calculate the NPV of the euro cash flows from the project. What is the NPV in dollars?

b. What are the dollar cash flows from the project if the company hedges against exchange rate changes? What is the NPV of these flows?

c. Suppose that the company expects the euro to depreciate by 5% a year. How does this affect the value of the project?

CHALLENGE

22. **Currency hedging** Alpha and Omega are U.S. corporations. Alpha has a plant in Hamburg that imports components from the United States, assembles them, and then sells the finished product in Germany. Omega is at the opposite extreme. It also has a plant in Hamburg, but it buys its raw material in Germany and exports its output back to the United States. How is each firm likely to be affected by a fall in the value of the euro? How could each firm hedge itself against exchange risk?

FINANCE ON THE WEB

Find the foreign exchange rate tables in the online version of *The Wall Street Journal* (**www.wsj.com**) or the *Financial Times* (**www.ft.com**).

1. a. How many U.S. dollars are worth one Canadian dollar today?

b. How many Canadian dollars are worth one U.S. dollar today?

c. Suppose that you arrange today to buy Canadian dollars in 90 days. How many Canadian dollars could you buy for each U.S. dollar?

d. If forward rates simply reflect market expectations, what is the likely spot exchange rate for the Canadian dollar in 90 days' time?

e. Look at the table of money rates in the same issue. What is the three-month interest rate on dollars?

f. Can you deduce the likely three-month interest rate for the Canadian dollar?

g. You can also buy currency for future delivery in the financial futures market. Look at the table of futures prices. What is the rate of exchange for Canadian dollars to be delivered in approximately six months' time?

2. a. How many Swiss francs can you buy for \$1?

b. How many Hong Kong dollars can you buy?

c. What rate do you think a Swiss bank would quote for buying or selling Hong Kong dollars? Explain what would happen if it quoted a cross-rate that was substantially above your figure.

MINI-CASE

Exacta, s.a.

Exacta, s.a., is a major French producer, based in Lyons, of precision machine tools. About two-thirds of its output is exported. The majority of these sales is within the European Union. However, the company also has a thriving business in the United States, despite strong competition from several U.S. firms. Exacta usually receives payment for exported goods within two months of the invoice date, so that at any point in time, only about one-sixth of annual exports to the United States is exposed to currency risk.

The company believes that its North American business is now large enough to justify a local manufacturing operation, and it has recently decided to establish a plant in South Carolina. Most of the output from this plant will be sold in the United States, but the company believes that there should also be opportunities for future sales in Canada and Mexico.

The South Carolina plant will involve a total investment of $380 million and is expected to be in operation by the year 2021. Annual revenues from the plant are expected to be about $420 million, and the company forecasts net profits of $52 million a year. Once the plant is up and running, it should be able to operate for several years without substantial additional investment.

Although there is widespread enthusiasm for the project, several members of the management team have expressed anxiety about possible currency risk. M. Pangloss, the finance director, reassured them that the company was not a stranger to currency risk; after all, the company was already exporting about $320 million of machine tools each year to the United States and has managed to exchange its dollar revenue for euros without any major losses. But not everybody was convinced by this argument. For example, the CEO, Mme. B. Bardot, pointed out that the $380 million to be invested would substantially increase the amount of money at risk if the dollar fell relative to the euro. Mme. Bardot was notoriously risk-averse on financial matters and would push for complete hedging if practical.

M. Pangloss attempted to reassure the CEO. At the same time, he secretly shared some of the anxieties about exchange rate risk. Nearly all the revenues from the South Carolina plant would be in U.S. dollars, and the bulk of the $380 million investment would likewise be incurred in the United States. About two-thirds of the operating costs would be in dollars, but the remaining one-third would represent payment for components brought in from Lyons plus the charge by the head office for management services and use of patents. The company has yet to decide whether to invoice its U.S. operation in dollars or euros for these purchases from the parent company.

M. Pangloss is optimistic that the company can hedge itself against currency risk. His favored solution is for Exacta to finance the plant by a $380 million issue of dollar bonds. That way the dollar investment would be offset by a matching dollar liability. An alternative is for the company to sell forward at the beginning of each year the expected revenues from the U.S. plant. But he realizes from experience that these simple solutions might carry hidden dangers. He decides to slow down and think more systematically about the additional exchange risk from the U.S. operation.

QUESTIONS

1. What would Exacta's true exposure be from its new U.S. operations, and how would it change from the company's current exposure?
2. Given that exposure, what would be the most effective and inexpensive approach to hedging?