CHAPTER 1

Introduction

By now the headlines are familiar: "Gibson Greetings Loses $19.7 Million in Derivatives" . . . "Procter and Gamble Takes $157 Million Hit on Derivatives" . . . "Metallgesellschaft Derivatives Losses Put at $1.3 billion" . . . "Derivatives Losses Bankrupt Barings." Such popular press accounts could easily lead us to conclude that derivatives were not only *involved* in these losses, but were *responsible* for them as well. Over the past few years, derivatives have become inviting targets for criticism. They have become demonized—the "D" word—the junk bonds of the New Millennium. But what are they?

Actually, there is not an easy definition. Economists, accountants, lawyers, and government regulators have all struggled to develop a precise definition. Imprecision in the use of the term, moreover, is more than just a semantic problem. It also is a real problem for firms that must operate in a regulatory environment where the meaning of the term often depends on which regulator is using it.

Although there are several competing definitions, we define a *derivative* as a *contract that derives most of its value from some underlying asset, reference rate, or index*. As our definition implies, a derivative must be based on at least one underlying. An *underlying* is the asset, reference rate, or index from which a derivative inherits its principal source of value. Falling within our definition are several different types of derivatives, including commodity derivatives and financial derivatives. A *commodity derivative* is a derivative contract specifying a commodity or commodity index as the underlying. For example, a crude oil forward contract specifies the price, quantity, and date of a future exchange of the grade of crude oil that underlies the forward contract. Because crude oil is a commodity, a crude oil forward contract would be a commodity derivative. A *financial derivative,* the focus of this book, is a derivative contract specifying a financial instrument, interest rate, foreign exchange rate, or financial index as the underlying. For example, a call option on IBM stock gives its owner the right to buy the IBM shares that underlie the option at a predetermined price. In this sense,

an IBM call option derives its value from the value of the underlying shares of IBM stock. Because IBM stock is a financial instrument, the IBM call option is a financial derivative.

In practice, financial derivatives cover a diverse spectrum of underlyings, including stocks, bonds, exchange rates, interest rates, credit characteristics, or stock market indexes. Practically nothing limits the financial instruments, reference rates, or indexes that can serve as the underlying for a financial derivatives contract. Some derivatives, moreover, can be based on more than one underlying. For example, the value of a financial derivative may depend on the difference between a domestic interest rate and a foreign interest rate (i.e., two separate reference rates).

In this chapter, we briefly discuss the major types of financial derivatives and describe some of the ways in which they are used. In succeeding sections, we discuss four types of financial derivatives—forward contracts, futures, options, and swaps. We then turn to a brief consideration of *financial engineering*—the use of financial derivatives, perhaps in combination with standard financial instruments, to create more complex instruments, to solve complex risk management problems, and to exploit arbitrage opportunities. We conclude with a discussion of the markets for financial derivatives and brief comments on their social function.

FORWARD CONTRACTS

The most basic forward contract is a *forward delivery contract*. A forward delivery contract is a contract negotiated between two parties for the delivery of a physical asset (e.g., oil or gold) at a certain time in the future for a certain price fixed at the inception of the contract. The parties that agree to the forward delivery contract are known as *counterparties*. No actual transfer of ownership occurs in the underlying asset when the contract is initiated. Instead, there is simply an agreement to transfer ownership of the underlying asset at some future delivery date. A forward transaction from the perspective of the buyer establishes a *long position* in the underlying commodity. A forward transaction from the perspective of the seller establishes a *short position* in the underlying commodity.

A simple forward delivery contract might specify the exchange of 100 troy ounces of gold one year in the future for a price agreed on today, say $400/oz. If the discounted expected future price of gold in the future is equal to $400/oz. today, the forward contract has no value to either party *ex ante* and thus involves no cash payments at inception. If the *spot price* of gold (i.e., the price for immediate delivery) rises to $450/oz. one year

from now, the purchaser of this contract makes a profit equal to $5,000 ($450 minus $400, times 100 ounces), due entirely to the increase in the price of gold above its initial expected present value. Suppose instead the spot price of gold in a year happened to be $350/oz. Then the purchaser of the forward contract loses $5,000 ($350 minus $400, times 100 ounces), and she would prefer to have bought the gold at the lower spot price at the maturity date.

For the short, every dollar increase in the spot price of gold above the price at which the contract is negotiated causes a $1 per ounce loss on the contract at maturity. Every dollar decline in the spot price of gold yields a $1 per ounce increase in the contract's value at maturity. If the spot price of gold at maturity is exactly $400/oz., the forward seller is no better or worse off than if she had not entered into the contract.

From our example, we can see that the value of the forward contract depends not only on the value of the gold, but also on the creditworthiness of the contract's counterparties. Each counterparty must trust that the other will complete the contract as promised. A default by the losing counterparty means that the winning counterparty will not receive what she is owed under the terms of the contract. The possibility of default is known in advance to both counterparties. Consequently, this kind of forward contract can reasonably take place only between creditworthy counterparties or between counterparties who are willing to mitigate the credit risk they pose by posting collateral or other credit enhancements.

The most notable forward market is the foreign exchange forward market, in which current volume is in excess of one-third of a trillion dollars per day. Forward contracts on physical commodities are also commonly observed. Forward contracts on both foreign exchange and physical commodities involve *physical* settlement at maturity. A contract to purchase Japanese yen for British pounds three months hence, for example, involves a physical transfer of sterling from the buyer to the seller, in return for which the buyer receives yen from the seller at the negotiated exchange rate. Many forward contracts, however, are *cash-settled forward contracts*. At the maturity of such contracts, the long receives a cash payment if the spot price on the underlying prevailing at the contract's maturity date is above the purchase price specified in the contract. If the spot price on the underlying prevailing at the maturity date of the contract is below the purchase price specified in the contract, then the long makes a cash payment.

Forward contracts are important not only because they play an important role as financial instruments in their own right but also because many other financial instruments embodying complex features can be decomposed into various combinations of long and short forward positions.

FUTURES CONTRACTS

A *futures contract* is essentially a forward contract that is traded on an organized financial exchange such as the Chicago Mercantile Exchange (CME).[1] Organized futures markets as we know them arose in the mid-1800s in Chicago. Futures markets began with grains, such as corn, oats, and wheat, as the underlying asset. *Financial futures* are futures contracts based on a financial instrument or financial index. Today, financial futures based on currencies, debt instruments, and financial indexes trade actively. *Foreign currency futures* are futures contracts calling for the delivery of a specific amount of a foreign currency at a specified future date in return for a given payment of U.S. dollars. *Interest rate futures* take a debt instrument, such as a Treasury bill (T-bill) or Treasury bond (T-bond), as their underlying financial instrument. With these kinds of contracts, the trader must deliver a certain kind of debt instrument to fulfill the contract. In addition, some interest rate futures are settled with cash. A popular cash-settled interest rate futures contract is the CME's Eurodollar futures contract, which has a value at expiration based on the difference between 100 and the then-prevailing three-month London Interbank Offer Rate (LIBOR). Eurodollar futures are currently listed with quarterly expiration dates and up to 10 years to maturity. The 10-year deferred contract, for example, has an underlying of the three-month U.S. dollar LIBOR expected to prevail 10 years hence.

Financial futures also trade based on financial indexes. For these kinds of financial futures, there is no delivery, but traders complete their obligations by making cash payments based on changes in the value of the index. *Stock index futures* are futures contracts that are based on the value of an underlying stock index, such as the S&P 500 index. For these futures, movements in the index determine the gains and losses. Rather than attempt to deliver a basket of the 500 stocks in the index, traders settle their accounts by making cash payments that are consistent with movements in the index. Table 1.1 lists the world's major futures exchanges and the types of financial futures that they trade.[2] Financial futures were introduced only in the early 1970s. The first financial futures contracts were for foreign exchange, with interest rate futures beginning to trade in the mid-1970s, followed by stock index futures in the early 1980s.

Most futures transactions in the United States occur through the *open outcry* trading process, in which traders literally "cry out" their bids to go long and offers to go short in a physical trading "pit." This process helps ensure that all traders in a pit have access to the same information about the best available prices. In recent years, there have been several attempts to replicate the trading pit with online computer networks. Replicating the interactions of traders has proven to be a difficult task and computer-based

TABLE 1.1 World Futures Exchanges and the Financial Futures Contracts They Trade

Exchange	FX	IRF	Index
Chicago Board of Trade (USA)	♦	♦	
Chicago Mercantile Exchange (USA)	♦	♦	♦
EUREX (Germany and Switzerland)		♦	♦
London International Financial Futures Exchange (UK)		♦	♦
New York Board of Trade (USA)	♦		♦
Kansas City Board of Trade (USA)			♦
Mid–America Commodity Exchange (USA)	♦		
Bolsa de Mercadorios de Sao Paulo (Brazil)	♦	♦	♦
New York Mercantile Exchange (USA)			♦
London Securities and Derivatives Exchange (UK)			♦
Tokyo International Financial Futures Exchange (Japan)	♦	♦	
Osaka Securities Exchange (Japan)			♦
Tokyo Stock Echange (Japan)		♦	♦
Korea Stock Exchange (South Korea)			♦
Singapore Exchange (Singapore)	♦	♦	♦
Marche a Terme International de France (France)		♦	♦
Hong Kong Futures Exchange (China)	♦	♦	♦
New Zealand Futures Exchange (New Zealand)		♦	♦
Sydney Futures Exchange (Australia)		♦	♦
Montreal Exchange (Canada)		♦	♦
Toronto Futures Exchange (Canada)			♦
OM Stockholm AB (Sweden)		♦	♦
Cantor Financial Futures Exchange (USA)		♦	
BrokerTec Futures Exchange (USA)		♦	

Notes: FX indicates foreign exchange, IRF indicates interest rate futures, and Index indicates any of a variety of indexes, including stock indexes, interest rate indexes, and physical commodity indexes. The New York Board of Trade is the parent company of the Coffee, Sugar, and Cocoa Exchange, the New York Cotton Exchange, FINEX, and the New York Futures Exchange. In addition to the exchanges listed in the table, several other exchanges exist but are not operational.

Sources: Commodity Futures Trading Commission (CFTC), the *Wall Street Journal, Futures Magazine, Intermarket Magazine,* various issues, various exchange publications.

trading has not grown as fast as many industry professionals forecast a decade ago.

FORWARDS VERSUS FUTURES

To say that a futures contract is a forward contract traded on an organized exchange implies more than may be obvious. This is because trading on an organized exchange involves key institutional features aimed at overcoming the biggest problems traders face in using forward contracts: credit risk exposure, the difficulty of searching for trading partners, and the need for an economical means of exiting a position prior to contract termination.

To mitigate credit risk, futures exchanges require periodic recognition of gains and losses. At least daily, futures exchanges mark the value of all futures accounts to current market-determined futures prices. The winners can withdraw any gains in value from the previous mark-to-market period, and those gains are financed by the losses of the "losers" over that period.

Marking to market creates a difference in the way futures and forward contracts allow traders to lock in prices. With a forward contract, the price of the asset exchanged at delivery is simply the price specified in the contract. With a futures contract, the buyer pays and the seller receives the spot price prevailing at the delivery date. If this is so, then how is the price locked in? The answer is that gains and losses on a futures position are recognized daily so that over the life of the futures contract the accumulated profits or losses—coupled with the spot price at delivery—yield a net price corresponding with the futures price quoted at the time the futures position was established. The marking-to-market procedure requires that customers post a performance bond that, loosely speaking, covers the maximum daily loss on their futures position. Those who fail to meet their margin call have their positions liquidated by the exchange before trading resumes. But how does the exchange know what the maximum daily loss is? The answer is that the exchange imposes daily price limits on its contracts (both on the up side and the down side) to define the maximum loss. For example, the New York Mercantile Exchange limits price movements for its nearby crude oil contract to $7.50 per barrel from the previous day's settlement price. If the limit is hit, then trading halts for the day and can resume that day only at prices within the limit. The point is that marking-to-market—coupled with daily price limits—serve to reduce exposure to credit risk.

In addition to marking to market and price limits, futures exchanges use a clearinghouse to serve as the counterparty to all transactions. If two traders consummate a transaction at a particular price, the trade immediately

becomes two legally enforceable contracts: a contract obligating the buyer to buy from the clearinghouse at the negotiated price, and a contract obligating the seller to sell to the clearinghouse at the negotiated price. Individual traders thus never have to engage in credit risk evaluation of other traders. All futures traders face the same credit risk—the risk of a clearinghouse default. To further mitigate credit risk, futures exchanges employ additional means, such as capital requirements, to reduce the probability of clearinghouse default.

A second problem with a forward contract is that the heterogeneity of contract terms makes it difficult to find a trading partner. The terms of forward contracts are customized to suit the individual needs of the counterparties. To agree to a contract, the unique needs of contract counterparties must correspond. For example, a counterparty who wishes to sell gold for delivery in one year, may find it difficult to find someone willing to contract now for the delivery of gold one year from now. Not only must the timing coincide for the two parties, but both parties must want to exchange the same amount of gold. Searching for trading partners under these constraints can be costly and time consuming, leaving many potential traders unable to consummate their desired trades. Organized exchanges, by offering standardized contracts and centralized trading, economize on the cost of searching for trading partners.

A third and related problem with a forward contract is the difficulty in exiting a position, short of actually completing delivery. In the example of the gold forward contract, imagine that one party to the transaction decides after six months that it is undesirable to complete the contract through the delivery process. This trader has only two ways to fulfill his or her obligation. The first way is to make delivery as originally agreed, despite its undesirability. The second is to negotiate with the counterparty, who may in fact be perfectly happy with the original contract terms, to terminate the contract early, a process that typically requires an inducement in the form of a cash payment. As explained in Chapter 2, the existence of organized exchanges makes it easy for traders to complete their obligations without actually making or taking delivery.

Because of credit risk exposure, the cost and difficulty of searching for trading partners, and the need for an economical means of exiting a position early, forward markets have always been restricted in size and scope.[3] Futures markets have emerged to provide an institutional framework that copes with these deficiencies of forward contracts. The organized futures exchange standardizes contract terms and mitigates the credit risk associated with forward contracts. As we will see in Chapter 2, an organized exchange also provides a simple mechanism that allows traders to exit their positions at any time.

OPTIONS

As the name implies, an *option* is the right to buy or sell, for a limited time, a particular good at a specified price. Such options have obvious value. For example, if IBM is selling at $120 and an investor has the option to buy a share at $100, this option must be worth at least $20, the difference between the price at which you can buy IBM ($100) through the option contract and the price at which you could sell it in the open market ($120).

Prior to 1973, options of various kinds were traded over-the-counter. An *over-the-counter market* (OTC) is a market without a centralized exchange or trading floor. In 1973, the Chicago Board Options Exchange (CBOE) began trading options on individual stocks. Since that time, the options market has experienced rapid growth, with the creation of new exchanges and many kinds of new option contracts. These exchanges trade options on assets ranging from individual stocks and bonds, to foreign currencies, to stock indexes, to options on futures contracts.

There are two major classes of options, call options and put options. Ownership of a *call option* gives the owner the right to buy a particular asset at a certain price, with that right lasting until a particular date. Ownership of a *put option* gives the owner the right to sell a particular asset at a specified price, with that right lasting until a particular date. For every option, there is both a buyer and a seller. In the case of a call option, the seller receives a payment from the buyer and gives the buyer the option of buying a particular asset from the seller at a certain price, with that right lasting until a particular date. Similarly, the seller of a put option receives a payment from the buyer. The buyer then has the right to sell a particular asset to the seller at a certain price for a specified period of time. Options, like other financial derivatives, can be written on financial instruments, interest rates, foreign exchange rates, and financial indexes.

In all cases, ownership of an option involves the right, but not the obligation, to make a transaction. The owner of a call option may, for example, buy the asset at the contracted price during the life of the option, but there is no obligation to do so. Likewise, the owner of a put option may sell the asset under the terms of the option contract, but there is no obligation to do so. Selling an option does commit the seller to specific obligations. The seller of a call option receives a payment from the buyer, and in exchange for this payment, the seller of the call option (or simply, the "call") must be ready to sell the given asset to the owner of the call, if the owner of the call wishes. The discretion to engage in further transactions always lies with the owner or buyer of an option. Option sellers have no such discretion. They have obligated themselves to perform in certain ways if the owners of the options so desire.

As Table 1.2 shows, there are five options exchanges in the United States trading options on financial instruments, reference rates, and financial indexes. In many respects, options exchanges and futures exchanges are organized similarly. In the options market, as in the futures market, there is a seller for every buyer, and both markets allow offsetting trades. To buy an option, a trader simply needs to have an account with a brokerage firm holding a membership on the options exchange. The trade can be executed through the broker with the same ease as executing a trade to buy a stock. The buyer of an option will pay for the option at the time of the trade, so there is no more worry about cash flows associated with the purchase. For the seller of an option, the matter is somewhat more complicated. In selling a call option, the seller is agreeing to deliver the stock for a set price if the owner of the call so chooses. This means that the seller may need large financial resources to fulfill his or her obligations. The broker is representing the trader to the exchange and is, therefore, obligated to be sure that the trader has the necessary

TABLE 1.2 U.S. Options Exchanges and Options Traded

Chicago Board Options Exchange
Options on individual stocks
Long-term options on individual stocks
Options on stock indexes
Options on interest rates
American Stock Exchange
Options on individual stocks
Long-term options on individual stocks
Options on stock indexes
Options on exchange traded funds
Philadelphia Stock Exchange
Options on individual stocks
Long-term options on individual stocks
Options on stock indexes
Options on foreign currency
Pacific Exchange
Options on individual stocks
Long-term options on individual stocks
International Securities Exchange
Options on individual stocks

Note: This listing does not include options on futures contracts.

financial resources to fulfill all obligations. For the seller, the full extent of these obligations is not known when the option is sold. Accordingly, the broker needs financial guarantees from option writers. In the case of a call, the writer of an option may already own the shares of stock and deposit these with the broker. Writing call options against stock that the writer owns is called writing a *covered call.* This gives the broker complete protection because the shares that are obligated for delivery are in the possession of the broker. If the writer of the call does not own the underlying stocks, he or she has written a *naked option,* in this case a naked call. In such cases, the broker may require substantial deposits of cash or securities to insure that the trader has the financial resources necessary to fulfill all obligations.

The Option Clearing Corporation (OCC) serves as a guarantor to ensure that the obligations of options contracts are fulfilled for the selling and purchasing brokerage firms. Brokerage firms are either members of the OCC or are affiliated with members. The OCC provides credit risk protection by enforcing rigorous membership standards and margin requirements. The OCC also maintains a self-insurance program that includes a guarantee trust fund. As an additional safeguard, the OCC has the right to assess additional funds from member firms to make up any default losses. As in the futures market, the buyer and seller of an option have no direct obligations to a specific individual but are obligated to the OCC. Later, if an option is exercised, the OCC matches buyers and sellers and oversees the completion of the exercise process, including the delivery of funds and securities.

SWAPS

A *swap* is an agreement between two or more parties to exchange sets of cash flows over a period in the future. For example, Party A might agree to pay a fixed rate of interest on $1 million each year for five years to Party B. In return, Party B might pay a floating rate of interest on $1 million each year for five years. There are five basic kinds of swaps, *interest rate swaps, currency swaps, equity swaps, commodity swaps,* and *credit swaps.* Swaps can also be classified as "plain vanilla" or "flavored." An example of a plain vanilla swap is the fixed-for-floating swap described earlier. Some types of plain vanilla swaps can be highly standardized, not unlike the standardization of contract terms found on an organized exchange. With flavored swaps, numerous terms of the swap contract can be customized to meet the particular needs of the swap's counterparties.

Swaps are privately negotiated derivatives. They trade in an off-exchange, over-the-counter environment. Swap transactions are facilitated by dealers who stand ready to accept either side of a transaction (e.g., pay fixed

or receive fixed) depending on the customer's demand at the time. These dealers generally run a *matched book,* in which the cash flows on numerous transactions net to a relatively small risk exposure on one side of the market. Many of these matched trades are termed *customer facilitations,* meaning that the dealer serves as a facilitating agent, simultaneously providing a swap to a customer and hedging the associated risk with either an offsetting swap position or with a futures position. The dealer collects a fee for the service and, if the transaction is structured properly, incurs little risk. When exact matching is not feasible for offsetting a position, dealers typically lay off the *mismatch risk* (also known as the *residual risk*) of their dealing portfolio by using other derivatives. Interest rate swap dealers, for example, rely heavily on CME Eurodollar futures to manage the residual risks of an interest rate swap-dealing portfolio. Chapters 6 and 7 explore how swap dealers price their swap transactions and manage the risk inherent in their swap portfolios.

Because dealers act as financial intermediaries in swap transactions, they typically must have a relatively strong credit standing, large relative capitalization, good access to information about a variety of end users, and relatively low costs of managing the residual risks of an unmatched portfolio of customer transactions. Firms already active as financial intermediaries are natural candidates for being swap dealers. Most dealers, in fact, are commercial banks, investment banks, and other financial enterprises such as insurance company affiliates.

Swap customers, called *end users,* usually enter into a swap to modify an existing or anticipated risk exposure. Swaps have also been used to establish unhedged positions allowing the end user an additional means with which to speculate on future market movements. End users of swaps include commercial banks, investment banks, thrifts, insurance companies, manufacturing and other nonfinancial corporations, institutional funds (e.g., pension and mutual funds), and government-sponsored enterprises (e.g., Federal Home Loan Banks). Dealers, moreover, may use derivatives in an end-user capacity when they have their own demand for derivatives exposure. Bank dealers, for example, often have a portfolio of interest rate swaps separate from their dealer portfolio to manage the interest rate risk they incur in their traditional commercial banking practice.

The origins of the swaps market can be traced to the late 1970s, when currency traders developed currency swaps as a technique to evade British controls on the movement of foreign currency. The first interest rate swap occurred in 1981 in an agreement between IBM and the World Bank. Since that time, the market has grown rapidly. Table 1.3 shows the notional amount of swaps outstanding at year-end for 1987 to 2001. By the end of 2001, interest rate and currency swaps with $69.2 trillion in underlying notional principal were outstanding. Over 90 percent of the swaps reported in

TABLE 1.3 Value of Outstanding Interest Rate and Currency Swaps ($ Trillions of Notional Principal)

Year	Total Swaps Outstanding	Year	Total Swaps Outstanding
1987	$ .683	1995	$17.713
1988	1.010	1996	25.453
1989	1.539	1997	29.035
1990	2.312	1998	50.997
1991	3.065	1999	58.265
1992	3.851	2000	63.009
1993	6.177	2001	69.200
1994	11.303		

Note: Figures include interest rate swaps, foreign currency swaps, and interest rate options. ISDA, the Office of the Comptroller of the Currency (OCC), and the Bank for International Settlements (BIS) each conduct surveys of derivatives transactions. The three sources show similar year-to-year changes in activity, but report different absolute levels. The BIS survey, for example, reports a notional principal value of $111 trillion for year-end 2001 compared to ISDA's $69.2 trillion and the OCC's $45 trillion. We report ISDA's results because the data series go back further than the series of either the OCC or BIS.

Source: International Swaps and Derivatives Association (ISDA).

Table 1.3 are interest rate swaps and the remaining are currency swaps. Of these swaps, approximately 90 percent of currency swaps and 30 percent of interest rate swaps involved the U.S. dollar.[4]

Notional principal is simply the total principal amount used to calculate swap cash flows. Currency swaps have principal that actually is exchanged, interest rate swaps do not—hence, the term notional. In most cases, the cash flows actually exchanged are at least an order of magnitude smaller than the notional principal amount. Therefore, the notional amount underlying a swap reveals nothing about the capital actually at risk in that transaction. Despite these flaws, changes in notional principal over time provide a useful measure of growth in the market, if not absolute size.

Table 1.3 shows that swaps grew at a compounded annual rate of 39.1 percent over the 1987 to 2001 period. The growth of the swaps market has been the most rapid for any financial product in history.

Chapter 6 provides a basic introduction to the swaps market. The swaps market is growing rapidly because it provides firms facing financial risks a flexible way to manage that risk. We explore the risk management motivation that has led to this phenomenal growth in some detail.

FINANCIAL ENGINEERING

So far, we have described four types of derivatives—forwards, futures, options, and swaps. These derivatives serve as the financial building blocks for building more complex derivatives. We can view a complex derivative as a portfolio containing some combination of these building blocks. The process of building more complex financial derivatives from the elemental blocks is referred to as *financial engineering*.[5] Financial engineering is most often used to create custom solutions to complex risk management problems and to exploit arbitrage opportunities. But financial engineering can also be used to place leveraged bets on market movements and to engineer around portfolio constraints, tax laws, accounting standards, and government regulations.

Sometimes a combination of elemental building blocks will replicate an already existing building block instead of a new financial instrument. When the net cash flows of two building blocks held in the same portfolio are equivalent to the cash flows on some other building block, the position is called a *synthetic instrument* and the portfolio of original building blocks is said to be "synthetically equivalent" to the resulting building block whose cash flows are replicated. The purpose of creating synthetic instruments is often to exploit arbitrage opportunities between financial positions with equivalent cash flows.

One of the most important applications of financial engineering is to risk management. Some risks can be easily managed using the elemental building block derivatives, but other risks require the services of a financial engineer to design a custom solution. In this section, we show a simple example of how to manage risks with financial derivatives. We then consider some complexities that may call for a custom solution by a financial engineer.

A Simple Risk Management Example Using Building Block Derivatives

Assume that a pension fund expects to receive $1,000,000 in three months to invest in stocks. If the fund manager waits until the money is in hand, the fund will have to pay whatever prices prevail for the stocks at that time. This exposes the fund to risk because of the uncertain value of stocks three months from now. By contrast, the fund manager could use financial derivatives to

manage that risk. The manager could buy stock index futures calling for delivery in three months. If the manager buys stock index futures today, the futures transaction acts as a substitute for the cash purchase of stocks and immediately establishes the effective price that the fund will pay for the stocks it will actually purchase in three months. Let us say that the stock index futures trades at a quoted price of 100.00 index units, each unit being worth $1, and the fund manager commits to purchase 10,000 units. The manager now has a $1,000,000 position in stock index futures. This futures commitment does not involve an actual cash purchase. As explained in Chapter 2, purchasing a futures contract commits the buyer to a future exchange of cash for the underlying asset.

Three months later, let us assume that the index stands at 105.00, so the fund manager has a futures position worth $1,050,000 and a futures trading profit of $50,000. The manager can close this position and reap the $50,000 profit. At this time, the pension fund receives the anticipated $1,000,000 for investment. Because the index has risen 5 percent, the stocks the manager hoped to buy for $1,000,000 now cost $1,050,000. By combining the $50,000 futures profit with the $1,000,000 the fund receives for investment, the fund manager can still buy the stocks as planned. If the manager had not entered the futures market, the manager would not have been able to buy all of the shares that were anticipated, as the manager would have $1,000,000 in new investable funds, but the stocks would have risen in value to $1,050,000. By trading the futures contracts, the manager successfully reduced the risk associated with the planned purchase of shares, and the fund is able to buy the shares as it had hoped.

In this example of the pension fund, the stock market rose by 5 percent and the fund generated a futures market profit of $50,000 to offset this rise in the cost of stocks. However, the market could have just as easily fallen by 5 percent over this three-month period. If the stock index fell from 100.00 to 95.00, the fund's futures position would have generated a $50,000 loss. (The fund manager established a $1 million position at an index value of 100.00, so a drop in the index to 95.00 means that the manager's position is worth only $950.000, for a $50,000 loss.) In this case, the manager receives $1,000,000 for investment. The stocks the manager planned to buy now cost only $950,000 instead of the anticipated $1,000,000. Therefore, the manager pays $950,000 for the stocks and uses the remaining $50,000 to cover the losses in the futures market. With a drop in futures prices, the pension fund would have been better off to have stayed out of the futures market. Had it not traded futures, the fund could have bought the desired shares for $950,000 and still had $50,000 in cash.

By trading stock index futures in the way just described, the pension fund manager effectively establishes a price for the shares of $1,000,000. If

the stock market rises, the gain on the futures offsets the increase in the cost of the shares, and the pension fund still pays out the $1,000,000 it receives in new funds plus its futures market gains to acquire the shares. If the stock market falls, the loss on the futures is offset by the decrease in the cost of the shares. To acquire the shares and pay its loss in the futures market, the pension fund still pays out the full $1,000,000 it receives. Thus, the pension fund has used the futures market to secure an effective price of $1,000,000 for the shares. Once it enters the futures transaction, the pension fund knows that it will be able to buy the shares that it wants in three months when it receives the $1 million and that it will have no funds left over. Thus, the pension fund has used the futures market to reduce the risk associated with fluctuations in stock prices.

The example of the pension fund illustrates the usefulness of financial derivatives as a risk management tool. At the time the fund entered the market, it could not know whether stock prices would rise or fall. If the fund buys futures as described earlier and the stock market rises, the fund benefits by being in the futures market. However, if the fund buys futures and the stock market falls, the fund suffers by being in the futures market. By trading futures, the fund was effectively ensuring that it would pay $1,000,000 for the stocks it wished to purchase. This decision reduced risk. The decision protected against rising prices, but it sacrificed the chance to profit from falling stock prices.

Complexities in Risk Management and the Financial Engineer

In our example of the pension fund, the risk management problem faced by the pension fund manager was quite simple. A single futures position served to provide a virtually complete solution to manage the risk of an anticipated purchase of stock. Risk management problems are often much more complex. This section introduces some complexities that frequently arise.

Exchange-traded futures and options typically have fairly brief horizons. Financial futures trade actively for maturity dates of only a few months or years into the future. Exchange-traded stock options usually expire within one year. The financial risk facing firms often has a much longer horizon. For example, a firm issuing a bond with a fixed rate of interest may be undertaking a commitment as long as 30 years. The longer the horizon, the less satisfactory are exchange-traded derivatives as risk management tools.

As we describe in detail in the following chapters, exchanges trade derivatives based on a limited array of underlying instruments. Firms often face financial risks that are only partially correlated with the instruments that underlie financial futures or exchange-traded options. Faced with such

a situation, using a single financial derivative can be a poor solution to the risk management problem, and even a combination of exchange-traded instruments may not be satisfactory. For example, a U.S. auto firm might consider building a plant in Europe and financing it in euros over the 10 years it will require to build the plant. Such a transaction involves long-term interest rate risk and foreign exchange risk. It would be difficult to manage this risk with exchange-traded instruments alone.

Exchanges trade financial derivatives that are based on well-known and fairly simple instruments. Many times, however, firms encounter financial risks that have complex payoff distributions over an extended period. For example, a firm might issue a callable bond, an instrument that can be retired on demand by the issuer under the terms of the bond covenant. Such a complex security involves complex risks for both the issuer and the purchaser. Fully comprehending the risks associated with such an instrument may require the services of a financial engineer. Managing the risks associated with the bond would likely require an assortment of exchange-traded financial derivatives and perhaps one or more swap agreements as well.

Investing in financial instruments, borrowing, and raising funds through stock offerings all involve financial risk. Investors earn their living by understanding the risks to which they are exposed and managing those risks wisely. When the amounts at risk are small and when the instruments employed are simple, the financial risks can be comprehended readily. However, complex risk exposures involving substantial sums of money can be very important, yet difficult to manage, calling for the services of a financial engineer.

Financial Engineering and Structured Notes

Financial engineers can create new products by combining building-block derivatives with basic (nonderivative) financial instruments. For example, a *structured note* can be created by combining the cash flows on a traditional, corporate bond and a building-block derivative. Structured notes are also sometimes called *hybrid debt* because they are a hybrid combination of debt securities and financial derivatives.

Structured notes can contain embedded building block derivatives. Perhaps the simplest type of structured note is a *floating rate note* (FRN), or a note whose coupon payments are indexed to a floating interest rate such as LIBOR. The cash flows on a FRN can be decomposed into the cash flows on a fixed-coupon bond and a fixed-for-floating interest rate swap whose notional principal is the same as the face value of the bond and whose settlement dates correspond to the bond's coupon dates.

A structured note can also be engineered to include option-like payoffs. For example, the Stock Index Growth Notes (SIGNs) issued by the Republic

of Austria several years ago, were five-year notes that paid no coupons and returned a principal value to investors at maturity equal to the face value of the note or the percentage increase in the S&P 500 index of stocks. If the S&P 500 declined in value over the life of the note, investors received only the face value of the note. If the S&P 500 rose, however, investors received the percentage increase in the S&P 500 over the life of the note *plus* the face value of the note. The cash flows on the SIGNs thus were equivalent to the cash flows on a portfolio of a zero-coupon bond and a long, at-the-money call option on the S&P 500.

MARKETS FOR FINANCIAL DERIVATIVES

The broadest way to categorize the market environment for derivatives is to distinguish between those transactions privately negotiated in an off-exchange, over-the-counter environment and those conducted on organized financial exchanges. As we have seen, futures exchanges arose to solve some of the problems associated with over-the-counter trading of forward contracts. By mitigating credit risk exposure, economizing on the cost of searching for trading partners, and providing for an economical means of exiting a position prior to contract termination, the futures market grew to dwarf the forward markets that had existed previously. Similarly, the establishment of exchange-traded options led to an explosion in the volume of option trading and resulted in option markets that are much larger and more robust than the over-the-counter option markets that came before.

Just as organized exchanges emerged to overcome the limitations of over-the-counter markets, the swaps market has emerged to overcome the limitations of organized exchanges. Although only about 20 years old, the swaps market has grown tremendously and now dwarfs organized exchanges that trade financial derivatives. In a certain sense, these markets seem to have come full circle: Over-the-counter markets gave way to organized exchange trading of futures and options, and now the exchanges appear to be giving way to a new over-the-counter market. This section reviews the market forces that led to the introduction of trading on organized exchanges and now seem to be leading to an increasing role for over-the-counter markets.

Exchange versus Over-the-Counter Markets

Over-the-counter markets suffer from problems with credit risk when the trading parties do not know and trust each other. Further, liquidity can be low, due to the search costs in finding trading partners willing to take the other side of a desired transaction. Finally, positions in over-the-counter contracts can be difficult to exit before the prescribed termination date.

Organized exchanges have their own weaknesses. First, for some market participants, the standardized contracts traded on organized exchanges lack flexibility in contract terms. Second, exchanges are regulated by the federal government. While this regulation may provide benefits to some traders, it also restricts the kinds of trading that can be conducted. Third, futures and option exchanges are governed by a set of rules, separate from government rules, aimed at lowering the cost of trading and increasing trading volume. Although these rules help reduce overall trading costs, complying with them can be costly and constraining for many traders. We consider these issues in turn.

Contract standardization is a key feature of the exchange-trading environment. Contract standardization concentrates trading interest, helps lower the cost of trading by promoting market liquidity, and provides for an economical means of exiting a position prior to contract termination. But contract standardization comes at the expense of contract customization. For many traders, the terms specified in standardized exchange-traded contracts are not satisfactory for meeting their unique needs. The contracts available on the exchanges may not have the correct risk exposure characteristics or they may not have the appropriate time horizon. Exchange-traded futures and options have only a limited number of months before they expire, and they do not extend as far into the future as many traders would like. For these traders, the trading cost advantage of using standardized contracts is offset by the cost disadvantage of using an imperfect contract ill-suited for their needs. These traders have an incentive to turn to an over-the-counter derivatives dealer to negotiate the precise contract terms required to meet their customized needs.

Both futures and options exchanges are subject to regulation by the federal government. The Commodity Futures Trading Commission (CFTC) regulates the futures exchanges that trade all futures contracts and options on futures. The Securities Exchange Commission (SEC) regulates the options exchanges. These government regulations may enhance the trustworthiness of the market and may make the market function better in some respects, but complying with these regulations involves costs. Today, many large firms that trade financial derivatives are actively seeking to reduce their trading costs by using over-the-counter markets, particularly the swaps market. To counter this trend, U.S. futures exchanges endorsed the passage of the Commodity Futures Modernization Act of 2000, which, when fully implemented, should put a significant portion of exchange-traded derivatives on a more equal competitive footing with over-the-counter derivatives.

In addition to government regulation, the trading of futures and options is governed by exchange rules. The purpose of these rules is to lower the cost of trading and to increase trading volume. While these rules help reduce

overall trading costs and promote efficiency, compliance can be costly and constraining for many traders. For example, futures and options exchanges have rules requiring that all trades be publicly executed on the floor of the exchange. Large traders worry that these rules allow their trading activity to be discerned by rival traders, permitting them to glean confidential information about the large trader's positions and trading strategy. If Merrill Lynch starts to buy, the market may recognize that Merrill is trading and anticipate a very large order. Prices would rise in anticipation of the large order, and the increase in prices would mean that Merrill would have to pay more than expected to complete its purchase. To avoid the price impact of their orders, many large firms seek to arrange privately negotiated transactions away from the exchange. By trading in the over-the-counter market, Merrill might be able to quietly negotiate with a single counterparty and consummate the entire transaction in secrecy. By trading in the over-the-counter market, Merrill can potentially avoid the price impact of its large order, reduce its trading costs, and avoid signaling its trading intentions to the market. Large traders often prefer to trade in an over-the-counter environment where their privacy is maintained and where they can execute large transactions without calling attention to their trading activity.[6]

The choice of executing a transaction on an exchange or in the over-the-counter market ultimately depends on the total all-in cost of completing the transaction. This not only includes explicit trading costs such as fees, but also bid-ask spreads and market impact cost, as well as a calculation concerning the suitability of standardized versus customized contracts. As the cost of using over-the-counter markets has declined over the past decade, more and more traders are finding that they can meet their trading objectives in the over-the-counter market.

THE SOCIAL ROLE OF FINANCIAL DERIVATIVES

One question frequently asked about derivatives is whether these instruments have any redeeming social value. To many observers, derivative transactions appear to be nothing more than an elaborate game of "hide the ball." To these observers, it appears that risk is just being shuffled from one investor to another without creating anything of social value.

Traditionally, two social benefits have been associated with financial derivatives. First, as already seen, financial derivatives are useful in managing risk. Second, the market for financial derivatives generates publicly observable prices containing the market's assessment of the current and future economic value of certain assets. This is true not only for exchange-traded derivatives but also for several benchmark swap transactions conducted in

the over-the-counter market. Society as a whole benefits from financial derivatives markets in these two ways. Thus, the financial derivatives markets are not merely a gambling den, as some would allege. While financial derivatives trading *does* provide plenty of opportunity for gambling, these markets create genuine value for society as well.

From the point of view of society as a whole, the risk management and risk transference functions of financial derivatives provide a substantial benefit. Because financial derivatives are available for risk management, firms can undertake projects that might be impossible without advanced risk management techniques. For example, the pension fund manager discussed earlier in this chapter might be able to reduce the risk of investing in stocks and thereby improve the well-being of the pension fund participants. Similarly, the auto firm that seeks to build a plant in Europe might abandon the project if it is unable to manage the financial risks associated with it. Individuals in the economy also benefit from the risk transference role of financial derivatives. Most individuals who want to finance home purchases have a choice of floating rate or fixed rate mortgages. The ability of the financial institution to offer this choice to the borrower depends on the institution's ability to manage its own financial risk through the financial derivatives market.

Financial derivatives markets are instrumental in providing information to society as a whole. Financial derivatives increase trader interest and trading activity in the cash market instrument from which the derivative stems. As a result of greater attention, prices of the derivative and the cash market instrument will be more likely to approximate their true value. Thus, the trading of financial derivatives aids economic agents in *price discovery*—the discovery of accurate price information—because it increases the quantity and quality of information about prices. When parties transact based on accurate prices, economic resources are allocated more efficiently than they would be if prices poorly reflected the economic value of the underlying assets. As discussed in later chapters, the prices of financial derivatives give information about the future direction of benchmark financial instruments, interest rates, exchange rates, and financial indexes. Firms and individuals can use the information discovered in the financial derivatives market to improve the quality of their economic decisions, even if they do not trade financial derivatives themselves.

SUMMARY

This chapter provided a brief overview of financial derivatives, their markets, and applications. We considered futures, forwards, options, options on futures, and swaps. All of these instruments play an important role in risk

management, and we explored some simple examples of how traders can use derivatives to manage risks. Often these risks become complex. Financial engineering is a special branch of finance that creates tailor-made solutions to complex risk management problems and other financial problems using financial derivatives as building blocks.

Derivatives trading began with over-the-counter markets. In the early 1970s, futures and options exchanges developed for financial derivatives and these exchanges provided a great impetus to the development of markets for financial derivatives. In the past two decades we have witnessed a re-emergence of over-the-counter markets. We compared the benefits and detriments of exchange trading versus over-the-counter markets. Finally, we considered the social role of financial derivatives and found that these markets contribute to social welfare by providing for a better allocation of resources and by providing more accurate price information on which market participants can base their economic decisions.

QUESTIONS AND PROBLEMS

1. What are the two major cash flow differences between futures and forward contracts?

2. What is the essential difference between a forward contract and a futures contract?

3. What problems with forward contracts are resolved by futures contracts?

4. Futures and options trade on a variety of agricultural commodities, minerals, and petroleum products. Are these derivative instruments? Could they be considered financial derivatives?

5. Why does owning an option only give rights and no obligations?

6. Explain the differences in rights and obligations as they apply to owning a call option and selling a put option.

7. Are swaps ever traded on an organized exchange? Explain.

8. Would all uses of financial derivatives to manage risk normally be considered an application of financial engineering? Explain what makes an application a financial engineering application.

9. List three advantages of exchange trading of financial derivatives relative to over-the-counter trading.

10. Consider again the pension fund manager example in this chapter. If another trader were in a similar position, except the trader anticipated selling stocks in three months, how might such a trader transact to limit risk?

SUGGESTED READINGS

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