As we described in Chapter 1, the increased economic uncertainty first evident in the 1970s has altered the way financial markets function. As foreign exchange rates, interest rates, and commodity prices have become more volatile, corporations have discovered that their value is subject to various financial price risks in addition to the risk inherent in their core business.

To illustrate the effect of changes in a given financial price on the value of a company, we again use the concept of a risk profile, introduced in Chapter 2. Figure 3-1 presents a case in which an unexpected increase in financial price, $P$ (e.g., the treasury bill rate, the price of oil, or the dollar price of a yen), decreases the value of the firm, $V$. The difference between the actual price and the expected price is shown as $\Delta P$, and $\Delta V$ measures the resulting change in the value of the firm. Had $\Delta P$ remained small, as it did prior to the 1970s, the changes in firm value would have been correspondingly small. But, for many companies, the increased volatility of exchange rates, interest rates, and commodity prices (large $\Delta P$s) in the 1970s and 1980s has been a major cause of sharp fluctuations in share prices (large $\Delta V$s). With this greater potential for large swings in value, companies have begun exploring newer methods for dealing with financial risks.

For companies confronted with the increased volatility of financial prices, the first and most obvious approach was to try to forecast future

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prices more accurately. If changes in exchange rates, interest rates, and commodity prices could be predicted with confidence, then companies could avoid unexpected swings in value. In the context of Figure 3.1, if the actual price could be anticipated, \( \Delta P \) would equal zero and the value of the firm would thus remain unchanged. Because of the efficiency of the financial markets, however, attempts to outpredict the market are unlikely to be successful. (Indeed, many economists trying to outforecast the market listened that lesson the hard way.)

Because forecasting cannot be relied upon to eliminate risk, the remaining alternative is to manage the risks. Financial risk management can be accomplished by using on-balance-sheet transactions. For example, a company could manage a foreign exchange exposure resulting from foreign competition by borrowing in the competitor's currency or by moving production abroad. However, on-balance-sheet methods can be costly and, as firms such as Caterpillar have discovered, inflexible.

Alternatively, financial risks can be managed with the use of off-balance-sheet instruments: forwards, futures, swaps, and options. When we first began to examine these financial instruments, we were surprised by what seemed an insurmountable barrier to entry. Participants in the various markets and the trade publications seemed to possess specialized expertise applicable in only one market, to the exclusion of all the others. Adding to the complexities of the individual markets themselves is a wider of jargon: "ticks," "collars," "strike prices."

“straddles,” and so forth. Indeed, it looks to the novice like a Wall Street version of the Tower of Babel, with each group of market specialists speaking a different language.

In market contracts to this specialist approach, we will in this text take a generalist approach, treating forwards, futures, swaps, and options not as four unique instruments and markets, but rather as four instruments for dealing with a single problem—managing financial risk. Indeed, we are going to show how the off-balance-sheet instruments are like those plastic building blocks children snap together: They can be built from one another (or combined into larger creations).

Forward Contracts

Of the four instruments considered in this chapter, the forward contract is the oldest and, perhaps for this reason, the most straightforward. A forward contract obligates its owner to buy a given asset on a specified date at a price (known as the “exercise price”) specified at the origination of the contract. If, at maturity, the actual price is higher than the exercise price, the contract owner makes a profit; if the price is lower, the owner suffers a loss.

In Figure 3-2, the payoff profile for buying a forward contract is superimposed on the original risk profile. If the actual price at contract maturity is higher than the expected price, the inherent risk will lead to a decline in the value of the firm; however, this decline will be offset by

![Figure 3-2. Payoff Profile for Forward Contracts.](image)
the profit on the forward contract. Hence, for the risk profile illustrated, the forward contract provides a perfect hedge. (If the risk profile were positively instead of negatively sloped, the risk would be managed by selling instead of buying a forward contract.)

In addition to its payoff profile, two features of a forward contract should be noted. First, the default (or credit) risk of the contract is two-sided. The contract owner either receives or makes a payment, depending on the price movements of the underlying asset. Second, the value of the forward contract is conveyed only at the contract's maturity; no payment is made either at origination or during the term of the contract.

**Futures Contracts**

Although futures contracts on commodities have been traded on organized exchanges since the 1860s, financial futures are relatively new, dating from the introduction of foreign currency futures in 1972. The basic form of the futures contract is identical to that of the forward contract: a futures contract obligates its owner to purchase a specified asset at a specified exercise price on the contract maturity date. Thus, the payoff profile for the purchase of a forward contract presented in Figure 3-2 could equally well illustrate the payoff to the holder of a futures contract.

Like the forward contract, the futures contract has two-sided risk. But, in marked contrast to forwards, credit or default risk can be virtually eliminated in a futures market. Futures markets use two devices to manage default risk. First, instead of conveying the value of a contract through a single payment at maturity, any change in the value of a futures contract is conveyed at the end of the day in which it is realized. Look again at Figure 3-2. Suppose that, on the day after origination, the financial price rises and, consequently, the financial instrument has a positive value. In the case of a forward contract, this value change would not be received until contract maturity. With a futures contract, this change in value is received at the end of the day. In the language of the futures markets, the futures contract is "cash-settled," or "marked to market" daily.

Because the performance period of a futures contract is reduced via marking to market, the risk of default declines accordingly. Indeed, since the value of the futures contract is paid or received at the end of each day, it is not hard to see why Fischer Black likened a futures contract to
"a series of forward contracts. Each day, yesterday's contract is settled, and today's contract is written. That is, a futures contract is like a sequence of forward contracts in which the "forward" contract written on day 0 is settled on day 1 and is replaced, in effect, with a new "forward" contract reflecting the new day's expectations. This new contract is itself settled on day 2 and replaced, and so on until the day the contract ends.

The second feature of futures contracts that reduces default risk is the requirement that all market participants—sellers and buyers alike—post a performance bond called the margin. If a futures contract increases in value during the trading day, this gain is added to the margin account at the day's end. Conversely, if the contract loses value, this loss is deducted from the margin account. If the margin account balance falls below some agreed-upon minimum, the holder is required to post additional bond; that is, the margin account must be replenished as the holder's position will be closed out. Because the position will be closed before the margin account is depleted, performance risk is eliminated.

Note that the exchange itself has not been proposed as a device to reduce default risk. Daily settlement and the requirement of a bond reduce default risk, but the existence of an exchange (or clearinghouse) merely serves to transform risk. More specifically, the exchange deals with the two-sided risk inherent in forwards and futures by serving as the counterparty to all transactions. If a party wishes to buy or sell a futures contract, he or she buys from or sells to the exchange and, hence, needs to evaluate only the credit risk of the exchange, not the credit risk of some specific counterparty. The primary economic function


4. Keep in mind that buying a futures contract means taking a long position in the underlying asset. Conversely, selling a futures contract is equivalent to taking a short position.

5. When a contract is originated on the U.S. exchanges, an "initial margin" is required. Subsequently, the margin account balance must remain above the "maintenance margin." If the margin account balance falls below the maintenance level, the balance must be restored to the initial level.

6. Note that this discussion has ignored daily limits. If there are daily limits on the movement of futures prices, large changes in expectations about the underlying asset can effectively close the market. (The market opens immediately moves the limit and then is effectively closed until the next day.) Hence, there may be an instance in which the broker desires to close out a customer's position but is not able to do so immediately because the market is experiencing limit moves. In such a case, the transaction that performance risk is "eliminated" is too soon.
of the exchange is to reduce the costs of transacting in futures contracts. The anonymous trades made possible by the exchange, together with the homogenous nature of the futures contracts—in terms of standardized assets, exercise dates (four per year), and contract sizes—enables the futures market to become relatively liquid. However, as was made clear by the recent experience of the London Metal Exchange, the existence of the exchange does not in and of itself reduce default risk.7,4

In sum, a futures contract is much like a portfolio of forward contracts. At the close of business of each day, in effect, the existing "forward" contract is settled and a new one written.8 This daily settlement feature combined with the margin requirement allows futures contracts to eliminate the credit risk inherent in forwards.

Swap Contracts9

Because they were publicly introduced in 1981,11 swaps are commonly portrayed as one of the latest financing innovations. However, a swap contract is in essence nothing more complicated than a series of forward

8. From the point of view of the market, the exchange does not reduce default risk; that is, the expected default rate is not affected by the existence of the exchange. However, the existence of the exchange can alter the default risk faced by an individual market participant. For a futures contract bought from a specific individual, the default risk is determined by the default rate of that specific counterparty. If the same futures contract is bought through an exchange, the default risk depends on the default rate of the entire market. Moreover, to the extent that the exchange is capitalized by equity from its members, the perceived default risk is further reduced because the participant has a claim not against some specific counterparty, but against the exchange. Therefore, dealing through the exchange is in a sense purchasing an insurance policy from the exchange.
11. The currency swap transaction between IBM and the World Bank in 1981 is normally marked as the public introduction of swaps.
contracts are bought together. The credit risk attending swaps is somewhat less than that of a forward contract with the same maturity, but it is greater than that of a comparable futures contract.

As implied by its name, a swap contract obligates two parties to exchange, or swap, specified cash flows at specified intervals. The most common form is the interest rate swap, in which the cash flows are determined by two different interest rates.

Figure 3-3 (a) illustrates an interest rate swap from the perspective of a party who is paying out a series of cash flows determined by a fixed interest rate ($R_f$) in return for a series of cash flows determined by a floating interest rate ($R_f$). Figure 3-3 (b) serves to illustrate that this

12 Specifically, the interest rate swap cash flows are determined as follows: The two parties agree to some notional principal, $P$. (The principal is notional in the sense that it is used only to determine the magnitude of cash flows; it is not paid or received by either party.) At each settlement date $1, 2, \ldots, T$, the party illustrated makes a payment $R = RP$, where $P$ is the $T$-period fixed rate that exists at origination. At each settlement, the party illustrated receives $R = RP$, where $R$ is the floating rate for that period (e.g., at settlement date 2, the interest rate used is the one-period rate in effect at period 1).

Figure 3-3. (a) An Interest Swap. (b) An Interest Rate Swap as a Portfolio of Forward Contracts.
swap contract can be decomposed into a portfolio of forward contracts. At each settlement date, the party to this swap contract has an implicit forward contract on interest rates: the party is obligated to sell a fixed-rate cash flow for an amount specified at the origination of the contract.

In terms of our earlier discussion, this means that the solid line in Figure 3-2 could also represent the payoff from a swap contract. Specifically, this line would be consistent with a swap contract in which the party illustrated receives cash flows determined by \( P \) (say, the U.S. treasury bond rate) and makes payments determined by another price (say, LIBOR). Thus, in terms of their ability to manage risk, forwards, futures, and swaps all function in the same way.

Identical payoff profiles notwithstanding, the instruments differ with respect to default risk. The performance period of a forward is equal to its maturity; and because no performance bond is required, a forward contract is a pure credit instrument. Futures both reduce the performance period (to one day) and require a bond, thereby eliminating credit risk. Swap contracts use only one of these mechanisms to reduce credit risk: they reduce the performance period.\(^{13}\) This point becomes evident in Figure 3-3. Although the maturity of the contract is \( T \) periods, the performance period is generally not \( T \) periods but a single period. Thus, given a swap and a forward contract of roughly the same maturity, the swap is likely to impose far less credit risk on the counterparties to the contract than the forward.

At each settlement date throughout a swap contract, the changes in value are transferred between the counterparties. To illustrate this in terms of Figure 3-3, suppose that interest rates rise on the day after origination. The value of the swap contract illustrated has thus risen. This value change will be conveyed to the contract owner not at maturity (as would be the case with a forward contract) nor at the end of that day (as would be the case with a futures contract). Instead, at the first settlement date, part of the value change is conveyed in the form of a "difference check" paid by one party to the other. Thus, the performance period is reduced from that of a forward, but it is not so short as that of a futures contract.\(^{14}\) (Keep in mind that we are comparing instruments with the same maturity.)

\(^{13}\) There are instances in which a bond has been posted in the form of collateral. As should be evident, in such a case the swap becomes very like a futures contract.

\(^{14}\) We will show in Chapter 9 that unlike futures, for which all change in contract value is paid/received at the daily settlements, swap contracts convey only part of the total value change at the periodic settlements.
At this point we should stop to reinforce the two major points made so far. First, a swap contract, like a futures contract, is similar to a portfolio of forward contracts. Therefore, the payoff profiles for these three instruments are identical. Second, the primary difference among forwards, futures, and swaps is the amount of default risk they impose on counterparties to the contract. forwards and futures represent the extremes, with the swap being the intermediate case.

It is important to note that swaps do impose some credit risk. For this reason it is not surprising that commercial banks have become increasingly active in a market that was initiated, for the most part, by investment banks. It is also not hard to understand the underlying cause of the sharp difference of opinion that has arisen between commercial and investment banks over the "most advisable" evolutionary path for the swap market to follow. Because investment banks are not in the business of extending credit, they would much prefer swaps to become more like futures, that is, an exchange-traded instrument with bonded contract performance. Commercial banks, by contrast, stand to benefit if swaps remain a credit instrument; accordingly, they would prefer the credit risk to be managed by imposing capital requirements on the financial institutions arranging the swaps.

Option Contracts
As we have seen, the owner of a forward, futures, or swap contract has an obligation to perform. In contrast, an option gives its owner a right. An option giving its owner the right to buy an asset—a call option—is illustrated in Figure 3-4. (Here, once again, the financial price $P$ could be an interest rate, a foreign exchange rate, the price of a commodity, or the price of some other financial asset.) The owner of the contract illustrated has the right to purchase the asset at a specified future date at a price agreed upon today. Consequently, if $P$ rises, the value of the option also goes up. But because the option contract owner is not obligated to purchase the asset, the value of the option remains unchanged (at zero) if $P$ declines.15

The payoff profile for the owner of the call option is repeated in part (a) of Figure 3-5. In this case, the contract owner has bought the right to

15. For continuity, we continue to use the $\Delta V, \Delta P$ convention in figures. To compare these figures with those found in most texts, treat $\Delta V$ as deviations from mean $(\Delta V = V - \mu)$, and remember that $\Delta P$ measures deviations from expected price $(\Delta P = P - \mu)$.
Figure 3-4. The Payoff Profile of a Call Option.

...buy the asset at a specified price—the exercise (strike) price. (In Figures 3-4 and 3-5, the exercise price is implicitly equal to the expected price.)

The payoff profile for the party who sold the call option (also known as the call writer) is shown in part (b) of Figure 3-5. Note that the seller of the call option, not the buyer, has the obligation to perform. For example, if the owner of the option exercises his or her option to buy the asset, the seller of the option is obligated to sell the asset.

Besides the option to buy an asset, there is also the option to sell an asset at a specified price, known as a put option. The payoff to the buyer of a put is illustrated in part (c) of Figure 3-5, and the payoff for the seller of the put is shown in part (d).

In many instances, jargon does more to confuse than to clarify, and this is particularly true in the "buy/sell," "call/put" jargon of options. Suppose a party is exposed to rising interest rates; that is, an increase in interest rates reduces his or her wealth. As illustrated at the top of Figure 3-6, this party could eliminate the downside exposure by buying a call
or the interest rate (an interest rate "cap"). In terms of bond prices, the proper strategy for hedging this exposure is to buy a put on bonds. As Figure 3-6 illustrates, a call on interest rates is equivalent to a put on bonds. The same thing occurs in the foreign exchange market: a put on DM/$ is equivalent to a call on $/DM. (There have been times when two people have argued about whether something was a put or a call when, in fact, they were both right.)

So far we have considered only the payoffs for the option contracts. Figures 3-4 through 3-6 assume, in effect, that option premiums are neither paid by the buyer nor received by the seller. By making this assumption, we have sidestepped the thorniest issue: the valuation of option contracts. It is to this we now turn.

The breakthrough in option pricing theory came with the work of Fischer Black and Myron Scholes in 1973.16 Conveniently for our pur

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Figure 3-6. Hedging Exposures with Options.
The work of Black and Scholes demonstrated that a call option can be replicated by a continuously adjusting ("dynamic") portfolio of two securities: (1) forward contracts on the underlying asset and (2) riskless securities. As the financial price rises, the "call option-equivalent" portfolio contains an increasing proportion of forward contracts on the asset. Conversely, the portfolio contains a decreasing proportion of the asset as the price of the asset falls. Because this portfolio is effectively a synthetic call option, arbitrage activity should ensure that its value closely approximates the market price of exchange-traded call options. In this sense, the value of a call option—and, thus, the premium charged its buyer—is determined by the value of its option-equivalent portfolio.

Part (a) of Figure 3-7 illustrates a call option payoff profile that includes the premium. This figure (like all of the option figures so far) illustrates an at-the-money option: an option for which the exercise price is the prevailing exercise price. As parts (a) and (b) of Figure 3-7 illustrate, an at-the-money option is paid for by sacrificing a significant amount of the firm's potential gains. However, the price of a call option falls as the exercise price increases relative to the prevailing price of the asset.

Alternatively, an out-of-the-money option, illustrated in part (c) of Figure 3-7, may be considered. As shown in part (d), the out-of-the-money option provides less downside protection, but the option premium is significantly less. The lesson to be learned here is that the option buyer can alter the payoff profile simply by changing the exercise price.

For the purposes of this discussion, the most important feature of options is that they are not as different from other financial instruments as they might at first seem. Options do have a payoff profile that differs significantly from that of forward contracts (or futures or swaps). But, option payoff profiles can be duplicated by a combination of forwards and risk-free securities. Thus, we find that options have more in common with the other instruments than was apparent. Futures and swaps, as we saw earlier, are in essence nothing more than portfolios of forward
contracts; and options, as we have just seen, are very much akin to portfolios of forward contracts and risk-free securities.

This point is reinforced if we consider ways in which options can be combined. Consider a portfolio constructed by buying a call and selling a put with the same exercise price. As the top of Figure 3-8 illustrates, the resulting portfolio (long a call, short a put) has a payoff profile equivalent to that of buying a forward contract on the asset. Similarly, the bottom portion of Figure 3-8 illustrates that a portfolio made up by selling a call and buying a put (short a call, long a put) is equivalent to selling a forward contract. The relationship illustrated in Figure 3-8 is known formally as put-call parity. The special importance of this relationship in the present context is the "building block construction" it makes possible: two options can be "snapped together" to yield the payoff profile for a forward contract, which is identical to the payoff profile for futures and swaps.

In summary, although options differ from forwards, futures, and swaps in many ways, we have discovered two "building block" relations between options and the other three instruments: (1) Options can be
Figure 3.8. Put-Call Parity.
simulated by “snapping together” a forward, futures, or swap contract and a position in risk-free securities; (2) Calls and puts can be “snapped together” to become forwards.

The Financial Building Blocks

Forwards, futures, swaps, and options—no novice, they look very different from one another. And if you read the trade publications or talk to the participants in the four markets, the apparent differences among the instruments are likely to seem even more pronounced. It looks as if the only way to deal with these financial instruments is to pick one and become a specialist in that market, to the exclusion of the others.

However, it turns out that forwards, futures, swaps, and options are not really unique constructions but resemble those plastic building blocks that children snap together into complex creations. To understand the off-balance-sheet instruments, you don’t need a lot of market-specific knowledge; you just need to know how the instruments can be linked. As we have seen: (1) Futures are built by “snapping together” a package of forwards. (2) Swaps are similarly built by “snapping together” a package of forwards. (3) Options can be built by “snapping together” a forward and a riskless security. (4) Options can be “snapped together” to yield forward contracts; conversely, forwards can be “unsnapped” to yield a package of options.

Figure 3-9 characterizes each of the four instruments we have been discussing according to the shapes of their payoff profiles. It also serves as a reminder of the put-call parity between options and forwards, futures, or swaps. Figure 3-9 thus provides, in effect, the “instruction manual” for our box of financial building blocks. A quick look shows that although there can be many pieces in the box, there are only six basic shapes to be concerned with. The straight pieces come in three colors; we can obtain a forward payoff profile with either forwards (the red ones), futures (the yellow ones), or swaps (the blue ones). The kinked pieces are all the same color (white) because options can be combined to simulate a forward, a futures, or a swap.

In the next fourteen chapters we look at the individual instruments in detail. Chapters 4 and 5 deal with forwards. Chapters 6–8 describe futures. Swaps are discussed in Chapters 6–12, and Chapters 13–16 describe options. Although it is beneficial to have detailed information about how each instrument and the market within which it is traded
work, it is important not to lose sight of the "building block" nature of these financial instruments. Indeed, after a discussion of the reason a firm hedges, in Chapter 17, we conclude this book with a chapter that could actually best be described as "construction using the building blocks"—we are going to show how complicated financial instruments, the so-called hybrid securities, are constructed using the building blocks.