1 Financial Markets

Imagine that our dear reader (that's you) was lucky enough to inherit one million dollars from a distant relative. This is more money than you want to spend at once (we assume), and you want to invest some of it. Your newly hired expert financial adviser tells you that an attractive possibility is to invest part of your money in the financial market (and pay him a hefty fee for the advice, of course). Being suspicious by nature, you don't completely trust your adviser, and you want to learn about financial markets yourself. You do a smart thing and buy this book (!) for a much smaller fee that pays for the services of the publisher and the authors (that's us). You made a good deal because the learning objectives of the first chapter are

- to describe the basic characteristics of and differences between the instruments traded in financial markets.
- to provide an overview of the organization of financial markets.

Our focus will be on the economic and financial use of financial instruments. There are many possible classifications of these instruments. The first division differentiates between securities and other financial contracts. A **security** is a document that confers upon its owner a financial claim. In contrast, a general **financial contract** links two parties nominally and not through the ownership of a document. However, this distinction is more relevant for legal than for economic reasons, and we will overlook it. We start with the broadest possible economic classification: bonds, stocks, and derivatives. We describe the basic characteristics of each type, its use from the point of view of an investor, and its organization in different markets.

Bonds belong to the family of **fixed-income securities,** because they pay fixed amounts of money to their owners. Other fixed-income instruments include regular savings accounts, money-market accounts, certificates of deposit, and others. Stocks are also referred to as **equities.** See figure 1.1 for a possible classification of financial instruments.

The financial instruments discussed in this chapter are **assets** a potential investor would consider as a part of his portfolio. This potential investor can be a person or an entity (a corporation, a pension fund, a country, . . .). In the economics and finance literature such a person or entity may be called a **trader,** an **agent,** a **financial investor,** and similar terms. We will name this investor **Taf.**

1.1 Bonds

In a very broad sense, a **bond** is a security (a document) that gives its owner the right to a fixed, predetermined payment, at a future, predetermined date, called **maturity.** The amount of money that a bond will pay in the future is called **nominal value, face value, par value,** or **principal.**

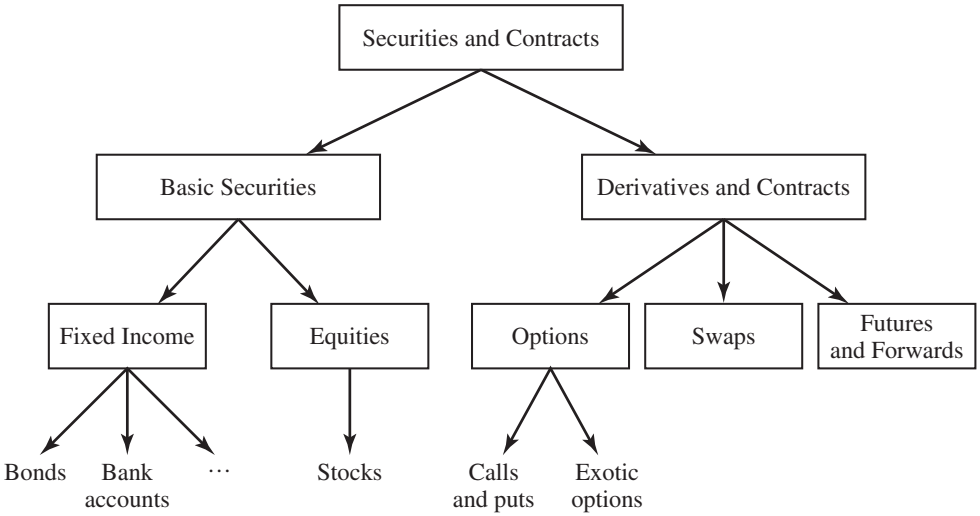

Figure 1.1
A classification of financial instruments: financial securities and contracts.

There are two sides to a bond contract: the party that promises to pay the nominal value, or the **debtor,** and the party that will get paid, or the **creditor.** We say that the debtor is a **counterparty** to the creditor in the bond contract, and vice versa. The debtor issues a bond in exchange for an agreed-upon amount called the **bond price** paid by the creditor. For example, the creditor may have to pay $95.00 today for a bond that pays $100.00 a year from today. The creditor can later sell the bond to another person who becomes the new creditor. The difference between the bond price the creditor pays to the debtor and the nominal value is called **interest.** The interest as a percentage of the total value is called **interest rate.** Typically, but not always, a bond with longer maturity pays a higher interest rate. A bond is characterized by its interest and its maturity. In principle, bonds represent the paradigm of **risk-free** securities, in the sense that there is a guaranteed payoff at maturity, known in advance. The lack of risk is the result of the certainty about that amount. In fact, in the models that we will examine in later chapters, we will always call bonds risk-free securities.

Money would fall into this broad definition of a bond. Money can be interpreted as a bond with zero interest rate and zero (immediate) maturity. The counterparty to the individual who has money is the government, guaranteeing the general acceptability of money as a payment instrument. A checking account is similar to money (although the counterparty is a bank). At the other extreme of the length of maturity, we have bonds issued by the government that expire in 30 years. Private corporations have issued bonds with longer maturities.

1.1.1 Types of Bonds

Depending on their maturity, bonds are classified into **short-term bonds,** or bonds of maturity no greater than one year, and **long-term bonds,** when their maturity exceeds one year. There are bonds that involve only an initial payment (the initial price) and a final payment (the nominal value). They are called **pure discount bonds,** since the initial price is equal to the discounted nominal value. Very often, however (especially with long-term bonds), the debtor will make periodic payments to the creditor during the life of the bond. These payments are usually a predetermined percentage of the nominal value of the bond and are called **coupons.** At maturity, the debtor will pay the last coupon and the nominal value. In this case, the nominal value part is called **principal.** The corresponding bonds are called **coupon bonds.** Actually, a coupon bond is equivalent to a collection, or a **basket,** of pure discount bonds with nominal values equal to the coupons. Pure discount bonds are also called **zero-coupon bonds,** because they pay no coupons. If the price at which the bond is sold is exactly the same as the nominal value, we say that the bond sells **at par.** If the price of the bond is different from the nominal value, we say that the bond sells **above par** if the price is higher than the nominal value, or **below par** if it is lower. Coupon bonds can sell at, above, or below par. Pure discount bonds always sell below par because the today's value of one dollar paid at a future maturity date is less than one dollar. For example, if Taf today lends $1,000 to his Reliable City Government for a ten-year period by buying a bond from the city, he should get more than $1,000 after ten years. In other words, a bond's interest rate is always positive.

1.1.2 Reasons for Trading Bonds

If a person has some purchasing power that she would prefer to delay, she could buy a bond. There are many reasons why someone might want to delay expending. As an example, our hard worker Taf may want to save for retirement. One way of doing so would be to buy bonds with a long maturity in order to save enough money to be able to retire in the future. In fact, if Taf knew the exact date of retirement and the exact amount of money necessary to live on retirement, he could choose a bond whose maturity matches the date of retirement and whose nominal value matches the required amount, and thereby save money without risk. He could also invest in bonds with shorter maturities and reinvest the proceeds when the bonds expire. But such a strategy will generally pay a lower interest rate, and therefore, the amount of money that will have to be invested for a given retirement target will be higher than if it were invested in the long-term bond.

Another example of the need to delay spending is the case of an insurance company, collecting premiums from its customers. In exchange, the insurance company will compensate the customer in case of fire or a car accident. If the insurance company could predict how

much and when it will need capital for compensation, it could use the premiums to buy bonds with a given maturity and nominal value. In fact, based on their experience and information about their customers, insurance companies can make good estimates of the amounts that will be required for compensation. Bonds provide a risk-free way to invest the premiums.

There are also many reasons why someone might want to advance consumption. Individual consumers will generally do so by borrowing money from banks, through house and car loans or credit card purchases. Corporations borrow regularly as a way of financing their business: when a business opportunity comes up, they will issue bonds to finance it with the hope that the profits of the opportunity will be higher than the interest rate they will have to pay for the bonds. The bonds issued by a corporation for financing purposes are called **debt.** The owner of bonds, the creditor, is called the **bondholder.** The government also issues bonds to finance public expenses when collected tax payments are not enough to pay for them.

1.1.3 Risk of Trading Bonds

Even though we call bonds risk-free securities, there are several reasons why bonds might actually involve risk. First of all, it is possible that the debtor might fail to meet the payment obligation embedded in the bond. This risk is typical of bonds issued by corporations. There is a chance that the corporation that issues the bond will not be able to generate enough income to meet the interest rate. If the debtor does not meet the promise, we say that the debtor has defaulted. This type of risk is called **credit risk** or **default risk.** The bonds issued by the U.S. government are considered to be free of risk of default, since the government will always be able to print more money and, therefore, is extremely unlikely to default.

A second source of risk comes from the fact that, even if the amount to be paid in the future is fixed, it is in general impossible to predict the amount of goods which that sum will be able to buy. The future prices of goods are uncertain, and a given amount of money will be relatively more or less valuable depending on the level of the prices. This risk is called **inflation risk.** Inflation is the process by which prices tend to increase. When Taf saves for retirement by buying bonds, he can probably estimate the amount of goods and services that will be required during retirement. However, the price of those goods will be very difficult to estimate. In practice, there are bonds that guarantee a payment that depends on the inflation level. These bonds are called **real bonds** or **inflation-indexed** bonds. Because of the high risk for the debtor, these bonds are not common.

A final source of risk that we mention here arises when the creditor needs money before maturity and tries to sell the bond. Apart from the risk of default, the creditor knows with certainty that the nominal value will be paid at maturity. However, there is no price guarantee before maturity. The creditor can in general sell the bond, but the price that the bond will reach before maturity depends on factors that cannot be predicted. Consider, for example,

the case of the insurance company. Suppose that the contingency the insurance company has to compensate takes place before the expected date. In that case, the insurance company will have to hurry to sell the bonds, and the price it receives for them might be lower than the amount needed for the compensation. The risk of having to sell at a given time at low prices is called **liquidity risk.** In fact, there are two reasons why someone who sells a bond might experience a loss. First, it might be that no one is interested in that bond at the time. A bond issued for a small corporation that is not well known might not be of interest to many people, and as a result, the seller might be forced to take a big price cut in the bond. This is an example of a liquidity problem. Additionally, the price of the bond will depend on market factors and, more explicitly, on the level of interest rates, the **term structure,** which we will discuss in later chapters. However, it is difficult in practice to distinguish between the liquidity risk and the risk of market factors, because they might be related.

1.2 Stocks

A **stock** is a security that gives its owner the right to a proportion of any profits that might be distributed (rather than reinvested) by the firm that issues the stock and to the corresponding part of the firm in case it decides to close down and liquidate. The owner of the stock is called the **stockholder.** The profits that the company distributes to the stockholders are called **dividends.** Dividends are in general random, not known in advance. They will depend on the firm's profits, as well as on the firm's policy. The randomness of dividend payments and the absence of a guaranteed nominal value represent the main differences with respect to the coupon bonds: the bond's coupons and nominal value are predetermined. Another difference with respect to bonds is that the stock, in principle, will not expire. We say "in principle," because the company might go out of business, in which case it would be liquidated and the stockholders will receive a certain part of the proceedings of the liquidation.

The stockholder can sell the stock to another person. As with bonds, the price at which the stock will sell will be determined by a number of factors including the dividend prospects and other factors. When there is no risk of default, we can predict exactly how much a bond will pay if held until maturity. With stocks there is no such possibility: future dividends are uncertain, and so is the price of the stock at any future date. Therefore, a stock is always a risky security.

As a result of this risk, buying a stock and selling it at a later date might produce a profit or a loss. We call this a **positive return** or a **negative return,** respectively. The return will have two components: the dividends received while in ownership of the stock, and the difference between the price at which the stock was purchased and the selling price. The difference between the selling price and the initial price is called **capital gain** or **loss.** The relation between the dividend and the price of the stock is called **dividend yield.**

1.2.1 How Are Stocks Different from Bonds?

Some of the cases in which people or entities delay consumption by buying bonds could also be solved by buying stock. However, with stocks the problem is more complicated because the future dividends and prices are uncertain. Overall, stocks will be more risky than bonds. All the risk factors that we described for bonds apply, in principle, to stocks, too. Default risk does not strictly apply, since there is no payment promise, but the fact that there is not even a promise only adds to the overall uncertainty. With respect to the inflation uncertainty, stocks can behave better than bonds. General price increases mean that corporations are charging more for their sales and might be able to increase their revenues, and profits will go up. This reasoning does not apply to bonds.

Historically, U.S. stocks have paid a higher return than the interest rate paid by bonds, on average. As a result, they are competitive with bonds as a way to save money. For example, if Taf still has a long time left until his retirement date, it might make sense for him to buy stocks, because they are likely to have an average return higher than bonds. As the retirement date approaches, it might be wise to shift some of that money to bonds, in order to avoid the risk associated with stocks.

So far we have discussed the main differences between bonds and stocks with respect to risk. From an economic point of view, another important difference results from the type of legal claim they represent. With a bond, we have two people or entities, a debtor and a creditor. There are no physical assets or business activities involved. A stockholder, however, has a claim to an economic activity or physical assets. There has to be a corporation conducting some type of business behind the stock. Stock is issued when there is some business opportunity that looks profitable. When stock is issued, wealth is added to the economy. This distinction will be crucial in some of the models we will discuss later. Stocks represent claims to the wealth in the economy. Bonds are financial instruments that allow people to allocate their purchasing decisions over time. A stock will go up in price when the business prospects of the company improve. That increase will mean that the economy is wealthier. An increase in the price of a bond does not have that implication.

In later chapters we will study factors that affect the price of a stock in more detail. For now, it suffices to say that when the business prospects of a corporation improve, profit prospects improve and the outlook for future dividends improves. As a result, the price of the stock will increase. However, if the business prospects are very good, the management of the company might decide to reinvest the profits, rather than pay a dividend. Such reinvestment is a way of financing business opportunities. Stockholders will not receive dividends for a while, but the outlook for the potential dividends later on improves. Typically, the stockholders have limited information about company prospects. For that reason, the dividend policy chosen by the management of the company is very important because it signals to the stockholders the information that management has.

1.2.2 Going Long or Short

Related to the question of how much information people have about company prospects is the effect of beliefs on prices and purchasing decisions: two investors might have different expectations about future dividends and prices. An "optimistic" investor might decide to buy the stock. A "pessimistic" investor might prefer to sell. Suppose that the pessimistic investor observes the price of a stock and thinks it is overvalued, but does not own the stock. That investor still can bet on her beliefs by **short-selling** the stock. Short-selling the stock consists in borrowing the stock from someone who owns it and selling it. The **short-seller** hopes that the price of the stock will drop. When that happens, she will buy the stock at that lower price and return it to the original owner. The investor that owes the stock has a **short position** in the stock. The act of buying back the stock and returning it to the original owner is called **covering the short position.**

Example 1.1 (Successful Short-Selling) Our reckless speculator Taf thinks that the stock of the company Downhill, Incorporated, is overvalued. It sells at $45 per share. Taf goes on-line, signs into his Internet brokerage account, and places an order to sell short one thousand shares of Downhill, Inc. By doing so he receives $45,000 and owes one thousand shares. After patiently waiting four months, Taf sees that the stock price has indeed plunged to $22 per share. He buys one thousand shares at a cost of $22,000 to cover his short position. He thereby makes a profit of $23,000. Here, we ignore transaction fees, required margin amounts, and inflation/interest rate issues, to be discussed later.

In practice, short-selling is not restricted to stocks. Investors can also short-sell bonds, for example. But short-selling a bond, for economic purposes, is equivalent to issuing the bond: the person who has a short position in a bond is a debtor, and the value of the debt is the price of the bond. In contrast to short-selling, when a person buys a security we say that she **goes long** in the security.

1.3 Derivatives

Derivatives are financial instruments whose payoff depends on the value of another financial variable (price of a stock, price of a bond, exchange rate, and so on), called **underlying.** As a simple example, consider a contract in which party A agrees to pay to party B $100 if the stock price of Downhill, Inc., is above $50 four months from today. In exchange party B will pay $10 today to party A.

As is the case with bonds, derivatives are not related to physical assets or business opportunities: two parties get together and set a rule by which one of the two parties will receive a payment from the other depending on the value of some financial variables. One

party will have to make one or several payments to the other party (or the directions of payments might alternate). The profit of one party will be the loss of the other party. This is what is called a **zero-sum game.** There are several types of financial instruments that satisfy the previous characteristics. We review the main derivatives in the following sections.

1.3.1 Futures and Forwards

In order to get a quick grasp of what a forward contract is, we give a short example first:

Example 1.2 (A Forward Contract) Our brilliant foreign currency speculator Taf is pretty sure that the value of the U.S. dollar will go down relative to the European currency, the euro. However, right now he does not have funds to buy euros. Instead, he agrees to buy one million euros six months from now at the exchange rate of $0.95 for one euro.

Let us switch to more formal definitions: **futures** and **forwards** are contracts by which one party agrees to buy the underlying asset at a future, predetermined date at a predetermined price. The other party agrees to deliver the **underlying** at the predetermined date for the agreed price. The difference between the futures and forwards is the way the payments are made from one party to the other. In the case of a forward contract, the exchange of money and assets is made only at the final date. For futures the exchange is more complex, occurring in stages. However, we will see later that the trading of futures is more easily implemented in the market, because less bookkeeping is needed to track the futures contracts. It is for this reason that futures are traded on exchanges.

A futures or a forward contract is a purchase in which the transaction (the exchange of goods for money) is postponed to a future date. All the details of the terms of the exchange have to be agreed upon in advance. The date at which the exchange takes place is called **maturity.** At that date both sides will have to satisfy their part of the contract, regardless of the trading price of the underlying at maturity. In addition, the exchange price the parties agree upon is such that the today's value of the contract is zero: there is a price to be paid at maturity for the good to be delivered, but there is no exchange of money today for this right/obligation to buy at that price. This price to be paid at maturity (but agreed upon today!) is called the **futures price,** or the **forward price.**

The "regular," **market price** of the underlying, at which you can buy the underlying at the present time in the market, is also called the **spot price,** because buying is done "on the spot." The main difference with the futures/forward price is that the value the spot price will have at some future date is not known today, while the futures/forward price is agreed upon today.

We say that the side that accepts the obligation to buy takes a **long position,** while the side that accepts the obligation to sell takes a **short position.** Let us denote by $F(t)$ the

forward price agreed upon at the present time t for delivery at maturity time T. By $S(t)$ we denote the spot price at t. At maturity time T, the investor with the short position will have to deliver the good currently priced in the market at the value $S(T)$ and will receive in exchange the forward price $F(t)$. The payoff for the short side of the forward contract can therefore be expressed as

$$F(t) - S(T)$$

The payoff for the long side will be the opposite:

$$S(T) - F(t)$$

Thus a forward contract is a zero-sum game.

1.3.2 Marking to Market

Futures are not securities in the strict sense and, therefore, cannot be sold to a third party before maturity. However, futures are **marked to market,** and that fact makes them equivalent, for economic purposes, to securities. Marking to market means that both sides of the contract must keep a cash account whose balance will be updated on a daily basis, depending on the changes of the futures price in the market. At any point in time there will be in the market a futures price for a given underlying with a given maturity. An investor can take a long or short position in that futures contract, at the price prevailing in the market. Suppose our investor Taf takes a long position at moment t, so that he will be bound by the price $F(t)$. If Taf keeps the contract until maturity, his total **profit/loss payoff** will be $F(t) - S(T)$. However, unlike the forward contract, this payoff will be spread over the life of the futures contract in the following way: every day there will be a new futures price for that contract, and the difference with the previous price will be credited or charged to Taf's cash account, opened for this purpose. For example, if today's futures price is \$20.00 and tomorrow's price is \$22.00, then Taf's account will be credited \$2.00. If, however, tomorrow's price is \$19.00, then his account will be charged \$1.00. **Marking to market** is a way to guarantee that both sides of a futures contract will be able to cover their obligations.

More formally, Taf takes a long position at moment t, when the price in the market is $F(t)$. The next day, new price $F(t+1)$ prevails in the market. At the end of the second day Taf's account will be credited or charged the amount $F(t+1) - F(t)$, depending on whether this amount is positive or negative. Similarly, at the end of the third day, the credit or charge will be $F(t+2) - F(t+1)$. At maturity day T, Taf receives $F(T) - F(T-1)$. At maturity we have $F(T) = S(T)$, since the futures price of a good with immediate delivery is, by definition, the spot price. Taf's total profit/loss payoff, if he stays in the futures contract

until maturity, will be

$$[S(T) - F(T-1)] + [F(T-1) - F(T-2)] + \cdots + [F(t+1) - F(t)] = S(T) - F(t)$$

This is the same as the payoff of the corresponding forward contract, except the payoff is paid throughout the life of the contract, rather than at maturity.

The investor, however, does not have to stay in the contract until maturity. She can get out of the contract by taking the opposite position in the futures contract with the same maturity: the investor with a long position will take a short position on the same futures contract. Suppose that the investor takes a long position at moment t and at moment $t + i$ wants out of the contract and takes a short position in the same contract with maturity T. The payoff of the long position is $S(T) - F(t)$, and the payoff of the short position is $F(t + i) - S(T)$, creating a total payoff of

$$S(T) - F(t) + F(t + i) - S(T) = F(t + i) - F(t)$$

Note that this is the same as the payoff of buying the contract at price $F(t)$ and selling it at price $F(t + i)$.

The system of marking to market makes it easy to keep track of the obligations of the parties in a futures contract. This process would be much more difficult for forward contracts, where for each individual contract it would be necessary to keep track of when the contract was entered into and at what price.

1.3.3 Reasons for Trading Futures

There are many possible underlyings for futures contracts: bonds, currencies, commodity goods, and so on. Whether the underlying is a good, a security, or a financial variable, the basic functioning of the contract is the same. Our investor Taf may want to use futures for **speculation,** taking a position in futures as a way to bet on the direction of the price of the underlying. If he thinks that the spot price of a given commodity will be larger at maturity than the futures price, he would take a long position in the futures contract. If he thinks the price will go down, he would take a short position. Even though a futures contract costs nothing to enter into, in order to trade in futures Taf has to keep a cash account, but this requires less initial investment than buying the commodity immediately at the spot price. Therefore, trading futures provides a way of borrowing assets, and we say that futures provide embedded **leverage.**

Alternatively, Taf may want to use futures for **hedging** risks of his other positions or his business moves. Consider, for example, the case of our farmer Taf who will harvest corn in four months and is afraid that an unexpected drop in the price of corn might run him out of business. Taf can take a short position in a futures contract on corn with maturity at the date of the harvest. In other words, he could enter a contract to deliver corn at the price of

$F(t)$ dollars per unit of corn four months from now. That guarantees that he will receive the futures price $F(t)$, and it eliminates any uncertainty about the price. The downside is that the price of corn might go up and be higher than $F(t)$ at maturity. In this case Taf still gets only the price $F(t)$ for his corn.

We will have many more discussions on hedging in a separate chapter later on in the text.

1.3.4 Options

In its simplest form, an **option** is a security that gives its owner the right to buy or sell another, underlying security, simply called **underlying,** at or before a future predetermined date for a predetermined price. The difference from the futures and forwards is that the owner of an option does not have to buy or sell if she chooses not to, which is why it is called an option. The option that provides its owner the right to buy is called a **call option.** For example, Taf can buy an option that gives him the right to buy one share of *Downhill, Inc.,* for $46.00 exactly six months from today. The option that provides its owner the right to sell is called a **put option.**

If the owner of the option can buy or sell *on a given date only,* the option is called a **European option.** If the option gives the right to buy or sell *up to (and including) a given date,* it is called an **American option.** In the present example, if it were an American option, Taf would be able to buy the stock for $46.00 at any time between today and six months from today.

If the owner decides to buy or sell, we say that the owner **exercises** the option. The date on which the option can be exercised (or the last date on which it can be exercised for American options) is called **maturity** or the **expiration date.** The predetermined price at which the option can be exercised is called the **strike price** or the **exercise price.** The decision to exercise an American option before maturity is called **early exercise.**

1.3.5 Calls and Puts

Consider a European call option with a maturity date T, providing the right to buy a security S at maturity T for the strike price K. Denote by $S(t)$ the value—that is, the spot price—of the underlying security at moment t. Each option contract has two parties involved. One is the person who will own the option, called a **buyer, holder,** or **owner** of the option. The other one is the person who sells the option, called a **seller** or **writer** of the option. On the one hand, if the market price $S(T)$ of the underlying asset at maturity is larger than the strike price K, then the holder will exercise the call option, because she will pay K dollars for something that is worth more than K in the market. On the other hand, if the spot price $S(T)$ is less than the strike price K, the holder will not exercise the call option, because the underlying can be purchased at a lower price in the market.

Example 1.3 (Exercising a Call Option) Let us revisit the example of Taf buying a call option on the Downhill, Inc., stock with maturity $T = 6$ months and strike price $K = \$46.00$. He pays \$1.00 for the option.

a. Suppose that at maturity the stock's market price is \$50.00. Then Taf would exercise the option and buy the stock for \$46.00. He could immediately sell the stock in the market for \$50.00, thereby cashing in the difference of \$4.00. His total profit is \$3.00, when accounting for the initial cost of the option.

b. Suppose that at maturity the stock price is \$40.00. Taf would not exercise the option. He gains nothing from holding the option and his total loss is the initial option price of \$1.00.

Mathematically, the payoff of the European call option that the seller of the call pays to the buyer at maturity is

$$\max[0, S(T) - K] = [S(T) - K]^+ \tag{1.1}$$

Here, x^+ is read "x positive part" or "x plus," and it is equal to x if x is positive, and to zero if x is negative. The expression in equation (1.1) is the payoff the seller has to cover in the call option contract because the seller delivers the underlying security worth $S(T)$, and she gets K dollars in return if the option is exercised—that is, if $S(T) > K$. If the option is not exercised, $S(T) < K$, the payoff is zero. Figure 1.2 presents the payoff of the European call option at maturity.

For the European put—that is, the right to sell $S(T)$ for K dollars—the option will be exercised only if the price $S(T)$ at maturity is less than the strike price K, because otherwise

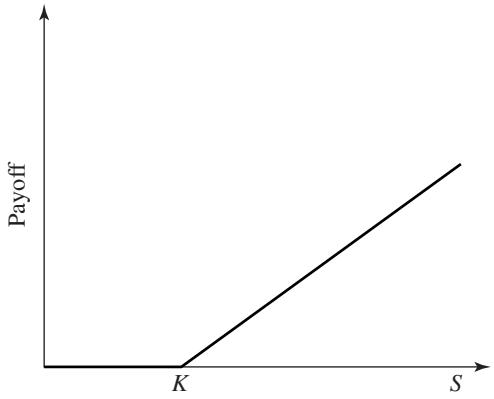

Figure 1.2
Call option payoff at exercise time.

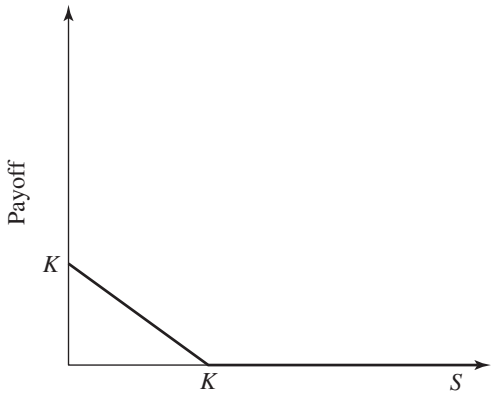

Figure 1.3
Put option payoff at exercise time.

the holder would sell the underlying in the market for the price $S(T) > K$. The payoff at maturity is then

$$\max[0, K - S(T)] = [K - S(T)]^+ \tag{1.2}$$

Figure 1.3 presents the payoff of the European put option at maturity.

An early exercise of an American option will not take place at time t if the strike price is larger than the stock price, $K > S(t)$, for a call, and if the strike price is smaller than the stock price, $K < S(t)$, for a put. However, it is not automatic that early exercise should take place if the opposite holds. For an American call, even when $S(t) > K$, the buyer may want to wait longer before exercising, in expectation that the stock price may go even higher. We will discuss in later chapters the optimal exercise strategies for American options.

In the case of a call (American or European), when the stock price is larger than the strike price, $S(t) > K$, we say that the option is **in the money.** If $S(t) < K$ we say that the option is **out of the money.** When the stock and the strike price are equal, $S(t) = K$, we say that the option is **at the money.** When the call option is in the money, we call the amount $S(t) - K$ the **intrinsic value** of the option. If the option is not in the money, the intrinsic value is zero. For a put (American or European), we say that it is in the money if the strike price is larger than the stock price, $K > S(t)$, out of the money if $K < S(t)$, and at the money when $S(t) = K$. When in the money, the put's intrinsic value is $K - S(t)$.

1.3.6 Option Prices

In an option contract, then, there are two parties: the holder has a right, and the writer has an obligation. In order to accept the obligation, the writer will request a payment. The payment

is called the **premium,** although usually we will call it the **option price.** As indicated earlier, when a person accepts the option obligation in exchange for the premium, we say that the person is **writing an option.** When a person writes an option, we say that she has a short position in the option. The owner of the option, then, is said to be long in the option. This terminology is consistent with the terms used in the discussion of stocks.

We started this section by saying that the underlying of an option is a financial instrument. That was the case historically, but today options are written on many types of underlyings. For example, there are options on weather, on energy, on earthquakes and other catastrophic events, and so on. The payoffs of corresponding call and put options will be as in equations (1.1) and (1.2), where $S(T)$ represents the value of a certain variable (for example, a weather index) at maturity. Simple puts and calls written on basic assets such as stocks and bonds are common options, often called **plain vanilla options.** There are many other types of options payoffs, to be studied later, and they are usually referred to as **exotic options.**

When an option is issued, the buyer pays the premium to the writer of the option. Later on, the holder of the option might be able to exercise it and will receive from the writer the corresponding payoff. The gain of one party is the opposite of the other party's loss; hence an option is a zero-sum game. The buyer of the option does not have to hold the option until maturity: the option is a security, and the owner of the option can always sell it to someone else for a price. One of the topics we cover later is the pricing of options. The price of an option (like the price of a bond and the price of a stock) will depend on a number of factors. Some of these factors are the price of the underlying, the strike price, and the time left to maturity.

1.3.7 Reasons for Trading Options

Options offer an interesting investment possibility for several reasons. First, they are widely used for **hedging** risk. A portfolio with a stock and a put option is equivalent to a portfolio in the stock with a limit on a possible loss in the stock value: if the stock drops in price below the strike price, the put option is exercised and the stock/option holder keeps the strike price amount. For example, a put option on a market index may be a convenient way to ensure against a drop in the overall market value for someone who is heavily invested in the stocks. This is the basis for **portfolio insurance,** which we will discuss later. Similarly, risk exposure to exchange-rate risk can be hedged by using exchange-rate options.

Example 1.4 (Using a Put Option for Hedging) Our conservative investor Taf has purchased one hundred shares of the stock of Big Blue Chip company as a large part of his portfolio, for the price of $65.00 per share. He is concerned that the stock may go down during the next six months. As a hedge against that risk he buys one hundred at-the-money European put options with six months' maturity for the price of $2.33 each. After six months the Big Blue Chip stock has gone down to $60.00 per share. Taf has lost

$100 \cdot 5.00 = 500$ dollars in his stock position. However, by exercising the put options, he makes $100 \cdot 5.00 = 500$ dollars. His total loss is the cost of put options equal to $100 \cdot 2.33 = 233$ dollars.

In addition to hedging, options can be attractive from an investment point of view because of the implicit **leverage,** that is, as a tool for borrowing money. Buying options is similar to borrowing money for investing in the stocks. However, this might be risky, as shown in the following example.

Example 1.5 Suppose that the Big Blue Chip stock has today's price of \$100. Imagine a weird stock market in which after one month there are only three possible prices of the stock: \$105, \$101, and \$98. A European call option on that stock, with strike price $K = 100$ and maturity in one month, has a price of \$2.50. Our optimistic investor Taf has \$100 to invest, and believes that the most likely outcome is the highest price. He could invest all of his capital in the stock and, after one month, he would get a relative return of

$$(105 - 100)/100 = 0.05 = 5\%, \qquad (101 - 100)/100 = 1\%, \quad \text{or } (98 - 100)/100 = -2\%$$

depending on the final price. However, the call option is increasing in the price of the stock, so Taf might decide to invest all his capital in the call option. He would be able to buy $100/2.5 = 40$ calls. The payoff of each call will be \$5.00 if the stock reaches the highest price, \$1.00 in the middle state, and \$0.00 in the lowest state (the option will not be exercised in that state). That payoff is all that will be left of the investment, since that is the end of the life of the option. The relative return for the investor in those states will then be

$$(5 \cdot 40 - 100)/100 = 1 = 100\%, \qquad (1 \cdot 40 - 100)/100 = -60\%, \quad \text{or } (0 - 100)/100 = -100\%$$

respectively.

We see that the investment in the call option really pays off if the stock increases to the highest value, but it means big losses otherwise. Investing in options is more risky than investing in stocks.

In the same way that buying a call is similar to buying the underlying, buying a put is similar to short-selling the underlying: the investor makes money when the price of the underlying goes down.

1.3.8 Swaps

Options and futures do not exhaust the list of financial instruments whose payoff depends on other financial variables. Another type of widely used derivative contract is a swap. We provide more details on swaps in a later chapter, and we only cover the basics here.

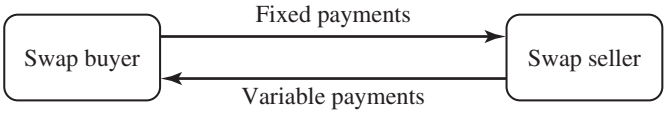

Figure 1.4
The buyer pays fixed interest and receives floating interest.

A **swap** is a contract by which two parties agree to exchange two cash flows with different features. For example, Taf has to pay a variable interest rate on his house mortgage loan, issued by bank A. However, he would rather be paying a fixed rate, because he does not like the fact that he cannot know what the variable rate will be each month. He could go to bank B, which trades swaps, and request a swap contract by which he would be paying bank B a fixed amount of interest each month, while in return bank B would be paying the variable interest to bank A. (This is an artificial example: in reality Taf would likely refinance his mortgage by having bank B pay the total debt to bank A at once, and not in monthly amounts.) A graphical illustration of a swap is given in figure 1.4.

A swap can be thought of as exchanging interest rates on two different types of bonds. Usually, only the interest-rate payments are exchanged, and not the principal. The principal amount is the same for both parties, and it is called the **notional principal.** It is only a reference amount, used to compute the coupon payments. In the most frequent type of swap, one party pays the other a **fixed interest rate** (on the notional principal) and receives in exchange a **floating interest rate.** Fixed interest means that the bond pays predetermined and constant coupons. Floating interest means that, each time a coupon is paid, the amount for the following payment is reset according to some rule. For example, the rate may be set equal to the current interest rate of the 30-year government bond plus 2%. The dates at which the exchanges take place and, therefore, the new coupons for the floating part are determined, are called **resetting dates.**

Very often the interest rates correspond to bonds denominated in different currencies. For example, one party pays the interest rate on a dollar-denominated bond, while the counterparty pays the interest rate on a yen-denominated bond. The two sides will exchange the interest rates as well as the currencies. The swaps where only the interest rate is exchanged are called **interest-rate swaps,** and they are called **currency swaps** if the currency is also exchanged. The side that will receive the floating rate **buys a swap,** while the side that will pay the floating rate **sells the swap.**

As in the case of options and futures, an investor might decide to buy or sell a swap for speculation purposes as a way to make money based on a change in interest rates, or swaps can be used as a hedging tool. In the former case, if Taf thinks that interest rates will go up, he would buy a swap, locking in the fixed rate he will have to pay in exchange

for the variable interest payment that, if the prediction is correct, will go up. As a hedging instrument, swaps are usually used by investors who have to pay a floating rate and receive a fixed rate. For example, a bank might have many clients to whom it pays a floating rate on certain accounts. But suppose that the bank is also providing a lot of mortgage loans, the majority of which pay a fixed rate. This is a risky situation for the bank because, if the interest rates go up, it might face losses, since it will not be able to pass the higher costs to its mortgage customers. One possible way to avoid that risk is to buy a swap. The bank will be paying the fixed interest rate, the cost of which can be covered by the funds received through the mortgages, and it will be receiving a floating rate that will allow it to pay the floating interest on the floating-rate accounts.

At the resetting date, when the interest payments are exchanged, the net result will be computed, and a single payment in one direction will take place: if the floating rate is higher than the fixed rate, the party that sold the swap will pay the difference between the two interests on the principal to the party that bought the swap. As in the case of options and futures, swaps are zero-sum games. One side's profit is the other side's loss. Swaps are also contracts (and, like futures, not securities), and the parties cannot sell them, but they can get out of them by taking the opposite position.

1.3.9 Mortgage-Backed Securities; Callable Bonds

There are other securities with characteristics that make them similar to derivatives. We mention two: **mortgage-backed securities,** or **MBS,** and **callable bonds.** We first describe the MBS. Suppose that a bank is providing mortgages to its clients. If these mortgages are similar, the bank can pool them together and issue securities that represent a proportional part of the pool of mortgages. These securities will then be sold to investors. The security serves two purposes: On one hand, it makes the borrowing of money available to house buyers that are looking for a loan. On the other hand, it allows private investors to access a type of investment that may be attractive given its return rate and its safety. The bank serves as an intermediary and keeps a small fraction of the interest paid by the house buyers to the lenders (the investors who bought the MBS).

If the mortgage rate is fixed, this type of financial instrument behaves like a regular bond with predetermined coupons. However, there is one difference: at any time before the end of the mortgage term the house buyer can decide to pay off the mortgage. This action is called **prepayment.** It makes the investment in the MBS risky because the prepayments are more likely to happen when the interest rates are dropping and, therefore, when the coupon paid by the MBS is more attractive. In fact, one way to analyze the MBS is by considering it a standard bond minus a call option on the loan (see Problem 20). That is, the buyer of the MBS is simultaneously buying a bond with fixed coupon and writing an American call

option on the bond with a strike price equal to the principal. If we can price both, we have a good approximation of the value of the MBS.

A similar interpretation is possible for callable bonds. **Callable bonds** are bonds with fixed interest rate and maturity, but such that the debtor has the possibility to repay the principal after some date prior to the scheduled maturity. As in the case of an MBS, a callable bond behaves like a standard bond minus a call on the bond with a strike price equal to the principal.

1.4 Organization of Financial Markets

Financial markets in the United States are the most developed financial markets, and we focus our attention on those. However, the organization of financial markets in most countries, in general, does not differ substantially from the structure that we will describe in the next few paragraphs.

Some securities and financial contracts can be purchased, or entered into, in markets with a physical location. Those markets are called **exchanges.** However, some securities and contracts are sold through sources without a physical location. We say that those financial instruments are traded **over the counter** or on an **OTC** market. Many contracts can be traded both on an exchange and on an OTC market. For example, many stocks, especially those of large companies, can be traded both on exchanges and OTC markets. However, treasury bonds, issued by the U.S. Treasury, the financial arm of the government, are traded on an OTC market, while corporate bonds are typically traded on exchanges. Another characteristic of exchanges as well as some organized OTC markets is the existence of a **market maker** that provides **liquidity** in a given security or contract. By this we mean that one of the obligations of the market maker is to guarantee that at every moment people can buy or sell a given security, or take a long or short position in a given contract, by offering these at appropriate prices.

1.4.1 Exchanges

In the United States there are two national stock exchanges, the **New York Stock Exchange,** or **NYSE,** which trades stocks of most of the largest companies, and the **American Exchange,** or **Amex,** which trades stocks of smaller companies. There are also several regional exchanges that list stocks of smaller companies. When an exchange lists a stock, the exchange guarantees that it can be bought or sold at the prevailing price in the market. At regional exchanges it is also possible to buy stocks of larger companies, like some of the companies listed on the NYSE. Stocks can also be bought OTC, without the need to go to any of those exchanges. There is also an organized OTC market that has become very

important in recent years: **Nasdaq,** the **National Association of Security Dealers Automated Quotation.** This is basically a network of computers with some strict rules about the way to perform trades. Many of the high-tech companies that have become some of the largest companies in the world in the last two decades are listed here. Securities listed on the NYSE, or any regional exchange, can also be bought at Nasdaq.

Treasury bonds, as we said before, can be traded only in an organized OTC market that is also a network of a few authorized dealers. Any private investor who wants to buy or sell treasury bonds will have to do so through these dealers. Corporate bonds are listed in some of the exchanges we mentioned before.

Most of the options traded on the markets are standardized according to some specific rules about the maturity, the strike price, and the underlying. These options trade on exchanges. An investor does not need to find a counterparty in order to take a long or short position in such options. The market maker will take the role of the counterparty for a market price. The largest option exchange is the **Chicago Board of Options Exchange,** or **CBOE.** The second-largest options exchange is the Amex. The Amex started as a stock exchange but now generates a large part of its business through options trades. Other stock exchanges also trade options. There is also a very active OTC market for options. For example, exotic options do not trade on exchanges. Rather, they are actively bought and sold OTC by investment banks.

Futures contracts are listed on exchanges. The most important futures exchanges are the **Chicago Board of Trade,** or **CBOT,** and the **Chicago Mercantile Exchange,** or **CME.** As in the case of options, the market makers guarantee that an investor can take a long or a short position in a given futures contract, at any point in time, at the market price.

In the United States there are two federal agencies that oversee the proper functioning of financial markets: the **Securities and Exchange Commission,** or **SEC,** and the **Commodities and Futures Trading Commission,** or **CFTC.** The SEC oversees the securities markets, stocks, and options, and the CFTC is in charge of the futures markets.

1.4.2 Market Indexes

Thousands of securities and contracts are listed on different exchanges. In order to summarize the information contained in their prices, there are many market indexes. An **index** tries to express through a single number a summary of the level of the markets, or a subset of markets. We mention a few of them. First, the **Standard & Poor's 500,** or **S&P 500,** is an average of the prices of 500 of the largest stocks listed on the NYSE or Nasdaq. It is not strictly the largest 500 stocks because the index tries to cover all industries. The average is weighted by **market capitalization value,** or the number of outstanding shares times the stock price. This is the amount it would cost to buy all the stock of a given company at a given moment in time. Periodically, the components of the index are updated.

Another important index is the **Dow Jones Industrial Average,** or **DJIA,** which is a weighted average of 30 of the most important companies. This is the oldest index. Its correlation with the S&P 500 is very high.

We should also mention the Nasdaq index, which is a weighted average, using the market capitalization value, of all the securities listed on Nasdaq. Since most of the high-tech companies have been trading in that market, that index is considered an indicator of the performance of the technology sector (the "new economy"). The **Russell 3000** is a weighted average of the largest 3,000 stocks of the economy. Given the increase in the number of public companies, it attempts to fill the role that the S&P 500 was playing 20 years ago. The **Russell 2000** is structured like the Russell 3000, but excluding the largest 1,000 stocks. It is representative of the performance of the stocks of the midsized and small companies. Very often, the performance of these companies has differed from the performance of the rest of the market. Finally, the **Wilshire 6000** index includes more than 7,000 companies, almost every public company in the United States, and it intends to be the broadest possible market index. The index is constructed by aggregating the market capitalization value of those companies.

1.5 Margins

Taking a position in some of the securities or contracts we have reviewed involves a potential financial responsibility. For example, a short position in an option could end up in a financial liability, should the option end up in the money. The same is true for both a long and a short position in a futures contract. In order to guarantee that the investor will be solvent at maturity, **margin requirements** are imposed. We describe the general functioning of margin requirements.

As a part of a margin requirement, some assets have to be deposited as **collateral** for a given debt, meaning they can be used to pay off the debt, if necessary. The amount required as collateral at the beginning of the trade is known as the **initial margin.** The difference between the collateral and the debt may change in the future because the value of the assets and the debt are in general **stochastic,** meaning random. After the initial trade takes place the investor is required to keep a minimum **maintenance margin** between the value of his collateral assets and his debt, which is typically set to a value smaller than the initial margin. When the value of the debt goes up or the value of the collateral goes down in such a way that the maintenance margin is not satisfied, the intermediary sends the investor a **margin call** that involves a request for more collateral or a cancellation of the debt. Often, extra collateral will be requested so that the initial margin is currently satisfied. When the investor does not attend the margin call, the intermediary will liquidate the account by selling the

assets and paying the debt. Margins are usually computed in such a way that there are enough assets to ensure the payment of the liability.

1.5.1 Trades That Involve Margin Requirements

Example 1.6 (Buying at Margin) Our enthusiastic investor Taf really likes the stock of the company called Uphill, Incorporated. He would like to buy $100,000 worth of the stock, but he has only $40,000 to invest. He decides to **buy at margin.** He goes to an intermediary, asking it to buy $100,000 worth of Uphill, Inc. He pays $40,000 to the intermediary, effectively borrowing $60,000. The intermediary keeps all the stock as a collateral against the amount lent. It also requires a maintenance margin of $70,000, meaning that the total value of the collateral should be at least $70,000. Suppose that three months from now the value of the total stock purchased falls to $65,000. Then the intermediary would send Taf a margin call for $5,000.

Getting a loan from a financial intermediary in order to buy stock is common practice in financial markets. As in the preceding example, a specific way to do so is to ask the intermediary to buy a larger amount of stock than the investor is paying for and have the intermediary pay for the difference. The stock so purchased is kept by the intermediary as a guarantee. This procedure is called **buying at margin.** The initial margin and the maintenance margin will determine the value of the required collateral relative to the value of the loan (which is fixed, from the moment the purchase takes place). Initially, the collateral is the stock purchased, and its value exceeds that of the loan, since all the stock, including that which the investor paid for, is used as collateral. The stock price fluctuates later on, thereby making the value of the collateral uncertain.

Another type of trade that involves the potential of financial responsibility is short-selling. In a short sale, the investor borrows and sells the stock, with the hope that its price will go down. There is a risk, however, that the price will go up. In that case the investor may have to buy the stock at a high price in order to get out of the short position. In order to guarantee that the investor will be able to meet the potential financial liability, a margin is required. Typically, the proceeds of the sale of the borrowed stock, plus some additional assets (typically cash), are required to satisfy the initial margin. As the value of the stock, and therefore the value of the debt, changes, the collateral will change in value. Such changes are fine as long as the maintenance margin is kept.

When an investor buys an option, her only obligation is to pay the price of the option. However, when an investor writes an option, a potential financial liability arises. When the investor writes a call, one possible way to guarantee the payment of the financial liability that would result in case the option expires in the money is by holding the stock simultaneously.

Since the payoff of the option cannot be larger than the value of the stock [see equation (1.1)], the stock is an adequate guarantee. This is called a **covered call.** The opposite is called a **naked call.** Both naked calls and short positions in puts are guaranteed by setting some margin requirements that will depend on how much the option is in the money at a given point in time.

An infamous example of how important margins can be is the case of a hedge fund run successfully for many years by a famous Wall Street wizard. A **hedge fund** is a name for a mutual fund whose activity is actually often risky and speculative in nature. These funds seek very high returns, and this approach usually means that the risk involved is also high. At one point the wizard's fund had a lot of short positions, including short positions in puts on the market index. Then one day the index suddenly fell, making the intrinsic value of the puts very high and prompting substantial margin calls on the fund. The fund could not satisfy the calls and went bankrupt. Even though the market recovered in the ensuing days, it was too late for the hedge fund.

Finally, both long and short positions in futures contracts involve the possibility of a financial responsibility. Both sides of the contract are requested to have an account that is upgraded every day as the contract is marked to market. In addition to charging or crediting the difference of the futures prices between today and yesterday, the accounts may be required to keep additional collateral in order to satisfy margin requirements. Mounting losses might force the investor to exit the futures contract before maturity. It is then possible that the investor might lose money in a position in futures because she cannot keep up with the margin requirements, even though she would have made money had she been able to stay in the contract until maturity.

The combination of marking to market and margin requirements is very important in practice for the functioning of futures markets. However, in our theoretical discussions in later chapters on pricing futures contracts and derivatives in general, we will usually ignore margin considerations.

In the next section we discuss costs and fees an investor has to pay in order to purchase a security. Margins are also usually costly. The cost is, in general, the result of keeping some collateral in the margin account, without getting the prevailing interest return in exchange. For example, the cash that is kept as a guarantee for a short sale may not pay an interest rate, or it may pay an interest rate lower than what the investor could get elsewhere.

1.6 Transaction Costs

The main cost of buying a security is its price. However, there are other costs the investor has to pay in order to perform the transaction. We call them **transaction costs.** We now mention the main costs other than the price of the security that an investor will face.

Intermediaries often require a fee or a commission as a compensation for the services they provide. The smaller the trade, the larger the proportional costs will be. Very large investors will pay negligible proportional fees. On the exchanges there is typically a market maker whose obligation is to guarantee that the investors will be able to buy or sell a given security (take long or short positions in a contract). In order to do so, the market maker will quote the price at which it would be willing to buy the security, called the **bid price,** and the price at which it would be willing to sell the security, called the **ask price.** The bid will be lower than the ask. The difference between the bid and ask price is called the **bid-ask spread.** It achieves two purposes. First, it is a part of the compensation the market maker receives for its services. Second, it is a means of protection from the possibility that the price might move against the market maker by going down if the market maker is buying, or up if the market maker is selling. In fact, the size of the bid-ask spread is a good indicator of the market volatility or risk underlying a given security. The bid-ask spread tends to be larger for smaller stocks that are harder to trade and therefore more risky.

The main cost component in large trades is the **price impact.** For example, when a big investor wants to sell a large number of shares of a certain stock, this decision will increase its supply dramatically, and the demand may not be very high. We say that the selling puts pressure on the stock price in the market, and, as a consequence, the price is likely to drop significantly. The investor will probably have to accept a price considerably lower than the price at which the stock had been trading before the large transaction was announced. There are special channels for large trades, as well as different strategies investors can choose in the case of a large transaction, all of them aimed at minimizing the price impact of the trade.

Summary

We have introduced three main types of financial contracts: bonds, stocks, and derivatives. A zero-coupon or pure discount bond pays a guaranteed payment, called nominal, face, principal, or par value, at a given future date, called maturity. A coupon bond also pays intermediate payments. Since the payment amounts are known, bonds are called risk-free securities, even though they may be exposed to default/credit risk, inflation risk, and liquidity risk.

A stock is a risky security whose value is tied to the performance and prospects of the company issuing the stock. A stock can also pay dividends, whose values depend on the profit of the company. An investor can borrow stocks to sell. This process is called short-selling. If the investor buys stocks, that action is called taking a long position in the stock.

Derivatives are securities whose value is determined from the value of another security (or some other financial variable), called the underlying. Futures and forwards are contracts