WILEY FINANCE

Derivatives demystified

A Step-by-Step Guide to Forwards, Futures, Swaps and Options

SECOND EDITION

ANDREW M. CHISHOLM

Derivatives Demystified

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Second Edition

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Dedicated to the memory of Mirek Piskáček

Profit . . . attaches to the creation of new things, to the realisation of the future value system. Without development there is no profit, and without profit no development. For the capitalist system it must be further added that without profit there would be no accumulation of wealth.

Joseph Schumpeter

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1

The Origins and Growth of the Market

DEFINITIONS

A **derivative** is an asset whose value is derived from that of some other asset, known as the **underlying**.

As an example, suppose you agree a contract with a dealer that gives you the **option** to buy a fixed quantity of gold at a fixed price of \$100 at any time in the next three months. The gold is currently worth \$90 in the world spot market. (A spot market is where a commodity or financial asset is bought or sold for immediate delivery.)

The option contract is a derivative and the underlying asset is gold. If the value of gold increases then so too does the value of the option, because it gives you the right (but not the obligation) to buy the metal at a fixed price. This can be seen by taking two extreme cases. Suppose that soon after the option contract is agreed the spot value of the gold specified in the contract rises to \$150. Alternatively, suppose the price collapses to \$50.

- **Spot Price Rises to \$150**. If this happens you can exercise (take up) the option, buy the gold for \$100 via the option and then sell the gold at a profit on the open market. The option has become rather valuable.
- **Spot Price Falls to \$50**. It is much cheaper to buy the gold in the spot market than to acquire it by exercising the option. Your option is virtually worthless. It is unlikely that it will ever be worth exercising.

As discussed in Chapter 8, because an option contract provides flexibility (it does not have to be exercised) an initial fee has to be paid to the dealer who writes or creates the option. This is called the **option premium**.

Derivatives are based on a very wide range of underlying assets. This includes metals such as gold and silver; commodities such as wheat and orange juice; energy resources such as oil and gas; and financial assets such as shares, bonds and foreign currencies. In all cases, the link between the derivative and the underlying commodity or financial asset is one of value. An option to buy a quantity of IBM shares at a fixed price is a derivative because if the underlying IBM share price increases then so too does the value of the option.

DERIVATIVES BUILDING BLOCKS

In the modern world there is a huge variety of different derivative products. These are either traded on **organized exchanges** or agreed directly with dealers in what is known as the **over-the-counter** (OTC) market. The good news is that the more complex structures are constructed from simple building blocks – forwards and futures, swaps and options. These are defined below.

Forwards

A forward contract is made directly between two parties. In a **physically delivered** forward contract one party agrees to buy an underlying commodity or financial asset on a future date at an agreed fixed price. The other party agrees to deliver that item at the stipulated price. Both sides are obliged to go through with the contract, which is a legal and binding commitment, irrespective of the value of the underlying at the point of delivery.

Some forward contracts are **cash-settled** rather than through the physical delivery of the underlying. This means that the difference between the fixed price stipulated in the contract and the actual market value of the underlying commodity or financial asset at the expiry of the contract is paid in cash by one party to the other.

Since forwards are privately negotiated, the terms and conditions can be customized. However, there is a risk that one side might default on its contractual obligation unless some kind of guarantee can be put in place.

Futures

A futures contract is essentially the same as a forward, except that the deal is made through an organized and regulated exchange rather than being negotiated directly between two parties.

In a physically delivered contract one side agrees to deliver a commodity or asset on a future date (or within a range of dates) at a fixed price, and the other party agrees to take delivery. In a cash-settled futures contract the difference between the fixed price and the actual market value of the underlying at expiry is settled in cash.

Traditionally there are three key differences between forwards and futures, although as discussed later the distinctions have blurred somewhat in recent years. Firstly, a futures contract is guaranteed against default. Secondly, futures are standardized, in order to promote active trading. Thirdly, profits and losses on futures are realized on a daily basis to prevent them from accumulating. The process is explained in detail in later chapters.

Swaps

A swap is an agreement made between two parties to exchange payments on regular future dates, where each payment leg is calculated on a different basis.

For example, suppose that a US company has to make interest payments on a euro loan over the next five years. Unfortunately its income is in US dollars, so it is exposed to changes in the exchange rate between the euro and the dollar. The firm can enter into a **currency swap** with a bank, in which the bank gives it the euros it needs on the required dates to make its loan payments. In return it makes payments to the bank in US dollars.

Although it is often considered as one of the most basic derivative products, a swap is actually composed of a series of forward contracts. Chapter 6 illustrates this fact with the example of an interest rate swap contract.

Options

A call option gives the holder the right to buy an underlying asset by a certain date at a fixed price. A put option conveys the right to sell an underlying asset by a certain date at a fixed price. As noted above, the purchaser of an option has to pay an initial fee called a premium

Table 1.1 Summary of four basic options strategies

Strategy	Premium	Characteristic
Buy a call	Pay	Right to buy the underlying at a fixed price.
Write a call	Receive	Obligation to deliver the underlying if exercised.
Buy a put	Pay	Right to sell the underlying at a fixed price.
Write a put	Receive	Obligation to take delivery of the underlying if exercised.

to the seller or writer of the contract. This is because the option provides flexibility for the purchaser – it need never be exercised.

Table 1.1 summarizes the four basic options strategies. Note that the most money the buyer of an option can ever lose on the deal is the initial premium paid for the contract. This is the case for a call and for a put option.

MARKET PARTICIPANTS

Derivatives have a very wide range of applications in business as well as in finance and banking. There are four main types of participants in the derivatives market: dealers, hedgers, speculators and arbitrageurs. However the same individuals and organizations may play different roles in different market circumstances.

Dealers

Derivatives contracts are bought and sold by dealers working for banks and securities houses. Some contracts are traded on exchanges, others are OTC transactions.

In a large investment bank the derivatives function is now a highly specialized affair. Marketing and sales staff speak to clients about their needs. Experts help to assemble solutions to those problems using combinations of forwards, swaps and options. Any risk that the bank assumes as a result of providing tailored products for clients is managed by the traders who run the bank's derivatives books. Meantime, risk managers keep an eye on the overall level of risk the bank is running; and mathematicians – known as 'quants' – devise the tools required to price new products.

Originally large banks tended to operate solely as intermediaries in the derivatives business, matching buyers and sellers. Over time, however, they assumed more and more risk themselves.

Hedgers

Corporations, investors, banks and governments all use derivative products to hedge or reduce their exposure to market variables such as interest rates, share prices, bond prices, currency exchange rates and commodity prices.

The classic example is the farmer who sells a futures contract to lock into a price for delivering a crop on a future date. The buyer might be a food processing company that wishes to fix a price for taking delivery of the crop in the future, or a speculator.

Another typical case is that of a company due to receive a payment in a foreign currency on a future date. It enters into a forward contract to sell the foreign currency to a bank and receive a predetermined quantity of domestic currency. Or it purchases an option which gives it the right but not the obligation to sell the foreign currency at a set rate.

Speculators

Derivatives are very well suited to speculating on the prices of commodities and financial assets and on market variables such as interest rates, stock market indices and currency exchange rates. Generally speaking, it is much less expensive to create a speculative position using derivatives than by trading the underlying commodity or financial asset. As a result, the potential returns are that much greater.

A classic case is the trader who believes that increasing demand or reduced supply is likely to boost the market price of oil. Since it would be too expensive to buy and store the physical commodity, the trader buys exchange-traded futures contracts agreeing to take delivery of oil on a future delivery date at a fixed price. If the oil price rises in the spot market, the value of the futures contracts will also rise and they can be sold back into the market at a profit.

In fact if the trader buys and then sells the futures contracts before they reach the delivery point the trader never has to take delivery of any actual oil. The profit from the trades is realized in cash.

Arbitrageurs

An arbitrage is a deal that produces risk-free profits by exploiting a mispricing in the market. A simple example occurs when a trader can buy an asset cheaply in one location and simultaneously arrange to sell it in another for a higher price. Such opportunities are unlikely to persist for very long, since arbitrageurs would rush in to buy the asset in the ‘cheap’ location, thus closing the pricing gap.

In the derivatives business arbitrage opportunities typically arise because a product can be assembled in different ways out of different building blocks. If it is possible to sell a product for more than it costs to buy the constituent parts, then a risk-free profit can be generated. In practice the presence of transaction costs often means that only the large market players can profit from such opportunities.

In fact many so-called arbitrage deals constructed in the financial markets are not entirely risk-free. They are designed to exploit differences in the market prices of products which are very similar, but not completely identical. For this reason they are sometimes (and more accurately) called **relative value** trades.

SUPPORTING ORGANIZATIONS

There are, in addition, many individuals and organizations supporting the derivatives market and helping to ensure orderly and efficient dealings. For example, those who are not members of a futures and options exchange have to employ a broker to transact or ‘fill’ their orders on the market. A broker acts as an agent and takes an agreed fee or commission. The smaller brokers operate through larger banks and securities houses.

Trading in derivatives generally is overseen and monitored by government-appointed regulatory organizations. For example, the US Commodity and Futures Trading Commission (CFTC) was created by Congress in 1974 as an independent agency to regulate commodity futures and options markets in the United States.

Market participants have also set up their own trade bodies, such as the International Swaps and Derivatives Association (ISDA) which promotes best practice in the OTC derivatives industry and develops and publishes legal documentation. (Chapter 20 discusses the widely-used ISDA Master Agreement.)

Trade prices on exchanges are reported and distributed around the world by electronic news services such as Reuters and Bloomberg. Finally, information technology companies provide essential infrastructure for the derivatives market, including systems designed to value derivative products, to distribute dealer quotations and to record and settle trades.

EARLY ORIGINS OF DERIVATIVES

The history of derivatives goes back a very long way. In Book One of his *Politics*, Aristotle tells a story about the Greek philosopher Thales who concluded (by means of astronomical observations) that there would be a bumper crop of olives in the coming year. Thales bought options on a large number of olive presses. He was not obliged to exercise the contracts if the harvest was poor – in which case his losses would have been restricted to the original price paid for the options.

In the event the harvest was excellent. Thales exercised his options and was then able to rent out the olive presses to others at a substantial profit. Some argued that this proves that philosophers can easily make money if they choose to, but that their minds are focused on higher things. Aristotle (who knew a thing or two about philosophy) was rather less impressed. He thought Thales' scheme was based on cornering or monopolizing the market for olive presses rather than any particularly brilliant insight into the prospects for the olive harvest.

Forwards and futures are equally ancient. In medieval times sellers of goods at European fairs signed contracts promising delivery on future dates. Commodity futures can be traced back to rice trading in Osaka in the 1600s. Feudal lords collected their taxes in the form of rice, which they sold in Osaka for cash. Successful bidders were issued with vouchers that were freely transferable. Eventually it became possible to trade standardized contracts on rice (similar to modern futures) by putting down a deposit that was a relatively small fraction of the value of the underlying rice.

The Osaka rice market attracted speculators, as well as hedgers who were seeking to manage the risks associated with fluctuations in the market value of the rice crop.

Tulip Mania and the Amsterdam Market

The tulip mania in sixteenth-century Holland, which saw bulbs being bought and sold in Amsterdam at hugely inflated prices, also saw the introduction of trading in tulip forwards and options. The bubble burst spectacularly in 1637. Derivatives on shares also appeared on the Amsterdam Stock Exchange by the seventeenth century. Traders could deal in call and put options which provided the right to buy or to sell shares on future dates at predetermined prices.

London superseded Amsterdam as Europe's main financial centre, and derivative contracts started to trade in the London market. The development was at times controversial. In the 1820s problems arose on the London Stock Exchange over trading in call and put options. Some members condemned the practice outright. Others argued that dealings in options greatly increased the volume of transactions on the exchange, and strongly resisted any attempts at interference.

The committee of the exchange tried to ban options, but it was eventually forced to back down when it became clear that some members felt so strongly about the matter that they were prepared to subscribe funds to found a rival exchange.

DERIVATIVES IN THE USA

Stock options (options on individual shares) were being traded in the US as early as the 1790s, very soon after the foundation of the New York Stock Exchange.

The next big step forward followed the foundation of the Chicago Board of Trade (CBOT) in 1848 by 83 Chicago merchants. The earliest forward contract (on corn) was traded on the CBOT in 1851 and the practice rapidly gained in popularity.

In 1865, following a number of defaults on forward deals, the CBOT formalized grain trading by developing standardized agreements called **futures contracts**. The exchange required buyers and sellers operating in the grain markets to deposit collateral called **margin** against their contractual obligations. Futures trading later attracted speculators as well as food producers and food-processing companies.

Trading volumes in the US expanded as new exchanges were formed in the late nineteenth and early twentieth centuries. The New York Cotton Exchange (later part of the New York Board of Trade) was founded in 1870. The Chicago Butter and Egg Board was founded in 1898, becoming the Chicago Mercantile Exchange (CME) in 1919. It became possible to trade futures contracts based on a wide range of commodities and (later) metals.

ICE

IntercontinentalExchange® (ICE) acquired the New York Board of Trade in 2007, which is now renamed ICE Futures U.S.® ICE also acquired the International Petroleum Exchange in 2001, now renamed ICE Futures Europe. ICE is a public company founded in 2000 and is a constituent of the S&P 500 index of top US shares.

Futures on financial assets are much more recent in origin. CME launched futures contracts on seven foreign currencies in 1972. In 1977 the CBOT introduced 30-year US Treasury Bond futures contracts, and in 1982 it created options on these futures contracts (see Chapters 4 and 12). In 1981 CME introduced a Eurodollar futures contract based on short-term US dollar interest rates, a key hedging tool for banks and traders. It broke new ground in being settled in cash rather than through the physical delivery of a financial asset (see Chapter 5).

The Chicago Board Options Exchange (CBOE) started up in 1973, founded by members of the CBOT. It revolutionized stock option trading by creating standardized contracts listed on a regulated exchange. Before that stock options in the USA were traded in informal over-the-counter markets. The CBOE first introduced calls on 16 underlying shares and later in 1977 launched put option contracts. Chapter 10 explores such products.

In 1983 the CBOE introduced options on the S&P 500 index of major US shares. In 1997 it launched options on the Dow Jones Industrial Average. By good fortune, just as the CBOE was starting up, the standard option pricing model developed by Black, Scholes and Merton was published. It became possible to value options on a common and consistent basis. The model is discussed in Chapters 13 and 14, and is set out in Appendix A.

CME Group

The two giant Chicago-based exchanges CBOT and CME finally merged in 2007. The combined entity is called CME Group. The group also includes the New York Mercantile Exchange (NYMEX). Its shares are listed on the US electronic stock market NASDAQ. CME Group revenues in 2009 totalled $2613 million.

OVERSEAS DEVELOPMENTS, INNOVATION AND EXPANSION

Based on US developments, the London International Financial Futures and Options Exchange (LIFFE) was set up in 1982. After a 1996 merger with the London Commodity Exchange it also began to offer a range of commodity futures contracts.

LIFFE was acquired by Euronext in 2002, which in turn merged in 2007 with the holding group that operates the New York Stock Exchange. Now NYSE Liffe is the global derivatives business of NYSE Euronext Group and operates derivatives markets in London, Amsterdam, Brussels, Lisbon and Paris.

NYSE Liffe's great rival in Europe is Eurex, which was created in 1998. It is jointly operated by Deutsche Börse AG and SIX Swiss Exchange and is a fully electronic market, without a physical trading floor. More than two billion contracts were traded on Eurex in 2008.

As the exchanges have continued to expand their operations, over-the-counter trading in forwards, swaps and options has also experienced an explosion of growth. The first interest rate swap was agreed as late as 1982.

The statistics at the end of this chapter show how rapidly the global derivatives market has grown and diversified. In the OTC market nowadays dealers offer a wide array of more complex derivatives, including later-generation option products with exotic-sounding names such as barriers, cliquets and digitals. These products are discussed in later chapters, with practical examples, and are also summarized in Appendix B.

AN EXAMPLE OF RECENT INNOVATION: WEATHER DERIVATIVES

Food producers and companies such as utilities have long been able to insure against natural catastrophes such as hurricanes or floods. By contrast weather derivatives, first introduced in the OTC market in 1997, can be used to hedge against the business risks associated with less extreme events. These include an unusually cold winter or high rainfall in the summer months.

Some Weather-Related Risks

1. An energy provider could suffer from lower sales in a warm winter or a cooler summer.
2. Energy users could face higher heating (cooling) costs in cold winters (warm summers).
3. A grain producer may be affected by an unusually hot summer that decreases crop yields.
4. A tourist and leisure business may be faced with lower revenues in a cold or rainy summer.

In general terms, weather derivatives are financial products whose payoffs are based on measurable weather factors (such as temperature or rainfall) recorded at specific reference locations.

The market has expanded since exchange-traded contracts were introduced on Chicago Mercantile Exchange in 1999. Almost one million contracts were traded on CME in 2007, although growth slowed somewhat in the financial markets crisis in 2008. In the OTC market a wide range of swaps and option contracts are negotiated.

TEMPERATURE-LINKED DERIVATIVES

The most widely used weather contracts are linked to temperature. CME lists a series of futures and options based on the average temperatures over a month or a season for various cities in the US and overseas.

In the winter months the exchange constructs a **Heating Degree Day (HDD)** index, and in the summer months a **Cooling Degree Day (CDD)** index. With the contracts for US cities that cover a one-month period, an HDD index measures the extent to which the average temperature each day in the month in a city is *below* a benchmark level of 65° F. For example, if the average temperature in New York one day in November 2009 is (say) 50° F then the HDD value for that day is as follows.

$$\text{Daily HDD value } = 65 - 50 = 15$$

The HDD index for New York for November 2009 is then calculated by adding the daily HDD values. This means that if the weather is unusually cold that month then the index will be high (it is likely that heating bills in New York will go up). If the weather is unusually mild in the month the HDD index will be low. Note that if the average daily temperature for one day is *above* 65° F then the HDD value for that day is set to zero.

The value connection

A derivative is a product whose value is derived from that of some underlying item. The underlying in this case is the HDD or CDD index. To make the 'value' connection, CME assigns a monetary value of \$20 to each HDD and CDD index point on the US city futures and options contracts.

For example, suppose it is early 2009 and an energy-using company in New York wishes to hedge against a colder winter. The November 2009 HDD futures contracts for New York are currently trading at 500 index points. If the company buys November futures and the actual index for November turns out to be (say) 600 points (reflecting a spell of colder weather in that month), then the futures contracts will close at a level of 600. The company will make a profit of \$2000 per contract. This can be used to offset its rising energy bills.

$$\text{Futures profit per contract} = (600 - 500) \times \$20 = \$2000$$

The profit on the futures hedge is paid in cash. The compensating losses are made by those traders who *sold* the HDD contracts at low levels, perhaps expecting a mild winter in New York.

Table 1.2 Hedging with CME weather futures contracts

Risk	Futures hedge	Potential user of the hedge
Hot summer	Buy CDD futures	Agricultural business that would suffer from lower crop yields.
Mild summer	Sell CDD futures	Drinks company that would face lower sales.
Mild winter	Sell HDD futures	Energy suppliers that would face lower demand.
Cold winter	Buy HDD futures	Construction company that would suffer from project delays.

Summary and basis risks

Table 1.2 summarizes how HDD and CDD futures can be used to hedge weather-related risks. It is also possible to trade option contracts on CME.

There is a potential **basis risk** in using standardized exchange-traded futures to hedge weather risk. A basis risk occurs when the hedging tool does not exactly match the risk that is being covered. This would happen, for example, if a company based *outside* New York used the New York HDD or CDD futures contracts to manage its exposure to unusual temperatures. Climate conditions may be somewhat different in the two locations. A specially-tailored OTC contract can provide a more exact hedge.

THE WILD BEAST OF FINANCE?

Derivatives quite clearly bring major advantages to the modern world of business and finance. Indeed it would be impossible for many corporations to manage their operations unless they could hedge their exposures to commodity prices, interest rates and currency exchange rates. Financial institutions also need to manage the risks associated with factors such as changes in bond and share prices and the creditworthiness of borrowers.

Derivatives Use

In a 2009 survey, the International Swaps and Derivatives Association found that 94% of the world's largest 500 companies (headquartered in 32 countries) used derivatives to manage business and financial risks.

However derivatives also make it possible for traders and speculators to take highly **leveraged** bets on markets. That is, they make it possible to take large speculative positions with the promise of huge potential profits, but for a small initial outlay. The other side of the coin is that the losses can be massive if the bets go wrong.

The problem is not simply that an entire organization can be wiped out through losses derived from speculative trading using derivative products. There is also the danger of **systemic risk**, that is, that there may be a contagion or 'domino' effect bringing down a large part of the financial system and crippling the economy in general. Panic can set in because it can become difficult to establish which other entities may be affected by the losses. In the process, perfectly sound institutions may suffer from the general crisis of confidence.

Recognizing this danger early, Alfred Steinherr wrote a highly prescient book in 1998 entitled *Derivatives: The Wild Beast of Finance* (published by John Wiley). Steinherr argued that the rapid growth in derivatives could destabilize global financial markets unless effective tools and measures for risk management were put in place.

Enter Warren Buffett

The point was taken up later in typically forthright style by the legendary investor Warren Buffet. In his 2002 letter to shareholders Buffet warned that:

> . . . derivatives are financial weapons of mass destruction, conveying dangers that, while now latent, are potentially lethal.

The examples from recent history in the next section illustrate the fact that such dangers are not illusory. The products discussed here, and the issues raised, are explored in more detail in the later chapters of this book.

LESSONS FROM RECENT HISTORY

This section outlines some of the more notorious episodes from the recent history of the derivatives markets. At the time of writing (early 2010), legislators and regulators are wrestling with understanding the role derivative products played in such events, and in particular in the global 'credit crunch' which started in 2007/8. They are also grappling with the implications for the future regulation of derivatives markets and financial institutions.

Hammersmith & Fulham Council (1988/9)

The London local authority entered into around 600 swap transactions in the late 1980s with a total notional value of some six billion pounds sterling. The amounts involved completely dwarfed the annual budget and the outstanding debt of the council. In effect, it was making a large speculative bet that UK interest rates would fall, rather than simply hedging its risks. In the event UK interest rates almost *doubled* in 1989 and the swap contracts moved into a substantial loss.

Unfortunately for the banks that were owed the money, the UK courts then decided that the swaps were *ultra vires*, that is, that a local authority had no legal power to enter into such speculative transactions. The deals were effectively cancelled, as were similar trades carried out by other British local authorities, resulting in substantial losses for a number of UK and international banks.

The case entered into the folklore of the derivatives industry and led to greater caution (for a time at least) over the legal and credit implications of swaps and other over-the-counter derivatives transactions.

Metallgesellschaft (1993)

The company was one of Germany's biggest conglomerates. Its subsidiary entered into a large number of forward contracts to supply oil products to customers for up to 10 years ahead at fixed prices. The buyers of the contracts included retailers and manufacturers seeking to hedge against potential increases in the oil price.

By entering into such deals Metallgesellschaft took on the risk itself that the price of oil would rise in the spot market. It decided to manage this risk by buying short-term exchange-traded energy futures and also similar products in the over-the-counter derivatives market. In theory, if the price of oil increased then any losses that arose from having to deliver oil products to customers on the supply contracts at fixed prices would be offset by profits on the futures contracts. (If the spot price of oil rose the futures would also increase in value.)

One reason for hedging in this way with short-term futures contracts is that they are highly **liquid**, i.e. they can be easily traded in large quantities on the exchange. As futures contracts approached their expiry date Metallgesellschaft replaced them with the next expiry month contracts, in a process known as ‘rolling’.

Unfortunately for Metallgesellschaft its futures hedge was imperfect. The price of oil fell sharply in late 1993. This incurred losses on the futures contracts, which have to be settled in cash on a regular basis. The compensating gains from being able to deliver oil on its forward delivery contracts to customers at what had then become high fixed prices would only be realized over 10 years. The company could run out of cash in the meantime. The matter is highly controversial, but the board decided to unwind all its obligations and lost around $1.3 billion. It was rescued by a bailout from a group of banks and had to sell off parts of the business.

Orange County (1994)

Orange County in California declared bankruptcy in December 1994 as a result of reported losses of more than $1.6 billion on its investment fund. The county treasurer Robert Citron had taken a large speculative bet based on a prediction of low US inflation and interest rates.

Part of the bet was implemented using new and exotic products called **reverse floaters** devised by specialists in banks. Unfortunately for Citron and Orange County, the US Federal Reserve actually started to *raise* interest rates during 1994. In such circumstances the losses on reverse floaters are greatly magnified. The resulting bankruptcy was the largest in US municipal history.

Barings Bank (1995)

The rogue trader Nick Leeson made losses of over 800 million pounds (GBP 800 million). His employer Barings, Britain’s oldest merchant bank, was later sold to the Dutch financial group ING for one pound. Leeson was supposed to be exploiting pricing anomalies (low-risk arbitrage opportunities) between futures contracts traded on the Singapore and on the Osaka exchanges based on the Japanese stock market index, the Nikkei 225.

In reality, Leeson took very large ‘long positions’ or one-way bets, buying futures contracts and betting that the Nikkei index would rise. He also sold call and put options on the Nikkei in a risky trade called a **short straddle.** This produces a profit if the market moves in a narrow range but can lose a great deal of money if the market becomes more volatile (see Chapter 17).

Leeson was able to conceal his unauthorized deals and the resulting losses because he was not only the firm’s ‘star trader’, but also ran the back-office accounting and settlement function in Singapore. (Chapter 20 discusses operational failures of this kind and the control measures banks now put in place.) His bosses in London were traditional merchant bankers with no experience of derivatives. The Nikkei index fell sharply after the Kobe earthquake in January 1995. Leeson then actually *increased* his long position in the futures, i.e. increased the size of his bet that the Nikkei index would rebound. Eventually massive losses were revealed.

Leeson fled Singapore but was captured and jailed. The case illustrated once again the need to keep trading and back-office functions separate. It also highlighted the risk that traders may be tempted to ‘double up’ loss-making positions to try to recoup their losses.

Long-Term Capital Management (1998)

LTCM was a hedge fund set up by the legendary bond trader John Meriwether. Members included the Nobel prize winners Robert Merton and Myron Scholes. LTCM's main bets were based on the idea that there would be convergence between the relative prices or returns available on safer and on riskier investments, and that any differentials or 'spreads' between the two that occurred over the short term would disappear over time.

Generally speaking the differentials involved were very small, and to make substantial returns for its fund holders LTCM borrowed large amounts of money and also used derivative products. Its big problems started in August 1998 when Russia defaulted on its debt and the prices of risky and of safer assets *widened* sharply. (This is sometimes called a 'flight to quality'.) LTCM was caught on the wrong side of this divergence and its losses were exaggerated by its high level of debt.

To prevent a systemic collapse in the financial markets, the Federal Reserve Bank of New York organized a $3.625 billion bailout of LTCM by a group of major banks.

One of the lessons of the crisis was that the mathematical models used by LTCM failed to take into account properly the possible occurrence and the damaging consequences of extreme market events such as the Russian default, which can lead to market panics and very rapid collapses in asset prices. In such circumstances highly leveraged funds can find themselves having to offload their assets at cheap prices to pay off their creditors, in a so-called 'fire sale'.

Enron (2001)

The Houston-based energy firm filed for bankruptcy in December 2001. It had been a leader in electricity and natural gas trading. It reported revenues of over $100 billion in 2000, more than double the 1999 figure.

Later investigations showed that Enron had used aggressive accounting techniques and derivative products to inflate its earnings and to boost the valuation of its assets. It created 'special partnerships' or **special purpose entities** to move billions of dollars of debt off its books.

Enron also boosted its income by booking profits up-front on trades that would take many years to mature. It valued energy contracts using the **mark-to-market** technique. This involves comparing the price at which a trade was entered into with its current value. However, unlike a simple asset such as a share, there was no publicly traded market that could establish the current value of Enron's contracts. As a result the managers had considerable discretion over the value that was reported.

In the wake of the Enron and other corporate scandals the US Congress passed the Sarbanes-Oxley Act in 2002. This set out new standards for the management and auditors of public firms, designed to ensure accurate financial disclosure.

Allied Irish Banks (2002)

AIB lost almost $700 million as a result of the activities of currency trader John Rusnak in a US subsidiary. Rusnak claimed to be operating a low-risk strategy by trading currency options and hedging the risks by trading in the spot and forward foreign exchange markets. This is an **arbitrage strategy** and is based on capturing price anomalies in the market.

In fact, though, Rusnak's initial options deals were fictitious and he faked the trade confirmation documentation (Chapter 20 discusses trade confirmation). He had made very large unhedged bets on currencies such as the Japanese yen. As losses mounted, Rusnak devised further means to cover up his positions. The internal audit processes and back-office monitoring procedures at AIB proved ineffectual.

AIG, Merrill Lynch and Lehman Brothers (2008)

The global 'credit crunch', which saw massive defaults on subprime mortgages made to higher-risk borrowers, reached a dramatic peak in September 2008. The US government had to take control of American Investment Group (AIG), one of the world's largest insurers. The \$85 billion deal was designed to forestall fears about the collapse of the financial system. AIG had sustained huge losses on credit derivatives (see Chapters 7 and 19) and other types of insurance protecting against default on assets tied to corporate debt and mortgage loans.

In the same month of September 2008 the US brokerage and securities firm Merrill Lynch, which had also lost heavily on so-called 'toxic assets', mostly linked to mortgage loans, was taken over by Bank of America in a \$50 billion deal. The most controversial event was the refusal of the US authorities to rescue the giant US investment bank Lehman Brothers. The ensuing bankruptcy created shockwaves in global markets and fears that other banks might fail. Units of Lehman Brothers were later acquired by Barclays Capital and Nomura.

CREATIVE DESTRUCTION AND CONTAGION EFFECTS

The great economist Joseph Schumpeter argued that the defining characteristic of a capitalist society is the existence of constant waves of innovation that bring about 'creative destruction'. By this he meant that under capitalism new technologies, products, operating procedures and forms of organizational structure are continuously developed. They sweep away the old ways, and in the process create additional wealth in society.

Rather disturbingly, though, the history of the derivatives business offers examples where financial innovations can carry such extreme dangers for the health of the overall economic system that regulators and governments are obliged to intervene. (Sometimes the intervention is rather too slow.) It turns out that certain innovations in finance affect not only the nature of competition within the banking industry. They have serious external or 'spillover' effects on other parties, including the taxpayers who have to pick up the bill if things go badly wrong.

The task for regulators and government for the future is to create a system that permits innovation and legitimate risk-taking in derivatives where this is truly beneficial to society at large, but without allowing market experts the licence to build the 'weapons of mass destruction' that Warren Buffet warned against in 2002.

THE MODERN OTC DERIVATIVES MARKET

Figure 1.1 gives an idea of the huge size of the modern global derivatives market. It also shows how the growth was slowed down to some extent by the 'credit crunch' and by critical events such as the Lehman Brothers bankruptcy in late 2008. The values are in trillions of US dollars. The figure for June 2008 stood at about \$684 trillion, before falling back to \$547 trillion in December 2008. By June 2009 it had recovered to \$605 trillion.

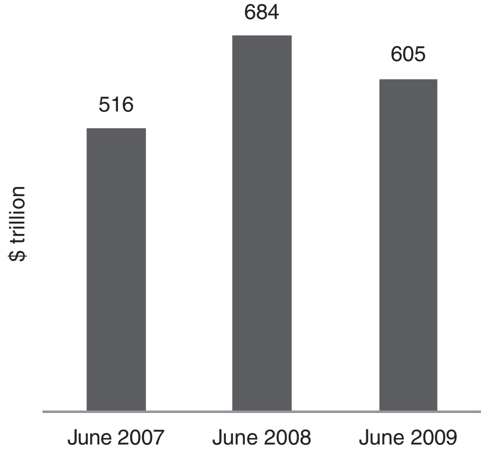

Figure 1.1 Notional amounts outstanding of OTC derivatives contracts at mid-year

Source: Based on data published by Bank for International Settlements available from www.bis.org

The notional amounts are enormous, although they can be a little misleading because with many contracts (such as interest rate swaps) the notional is never actually exchanged, and simply exists to calculate the payments due from one party to the other.

The **market value** of all OTC derivatives at June 2009 was around $25 trillion. In addition, many derivatives deals are used to hedge or match other deals so that in overall terms much of the risk actually cancels out.

Figure 1.2 breaks the notional amounts down by ‘risk category’ or asset class, i.e. the type of underlying assets on which the OTC derivative contracts are based. The largest market is still for contracts based on interest rates, and the majority of these are interest rate swaps. At mid-2009 the notional amount outstanding on interest rate swaps globally was about $342 trillion.

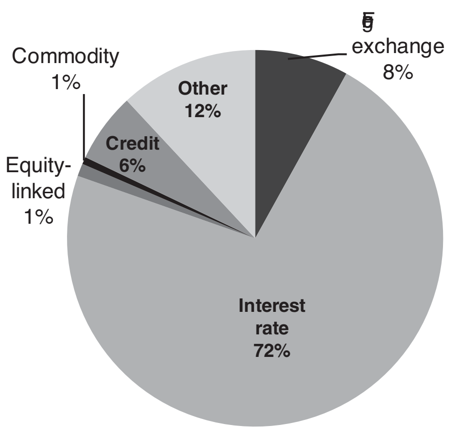

Figure 1.2 Global OTC derivatives at June 2009: notional amounts outstanding by type of underlying asset

Source: Based on data published by Bank for International Settlements available from www.bis.org

Table 1.3 Financial futures and options traded on organized exchanges. Notional principals outstanding in billions of US dollars

	At December 2007	At December 2008
Total futures	28 039	19 483
Interest rate futures	26 770	18 732
Currency futures	159	95
Equity index futures	1111	656
Total options	51 039	38 381
Interest rate options	44 282	33 979
Currency options	133	129
Equity index options	6625	4273

Source: Based on data published by Bank for International Settlements available from www.bis.org

The actual market value of those swaps transactions was approximately \$14 trillion. These figures reveal the extent to which swaps are used by banks and corporations to manage the risks associated with fluctuations in short-term interest rates.

The item for ‘credit’ in Figure 1.2 refers to **credit default swaps**, which are discussed in detail in Chapter 7 of this book. The notional amount outstanding worldwide on these particular deals reached \$58 trillion at end-2007. However in the wake of problems at AIG and elsewhere the figure for June 2009 had fallen back to \$36 trillion; a sharp reduction from previous highs but still a huge number.

THE EXCHANGE-TRADED DERIVATIVES MARKET

Following a period of stagnation, trading in exchange-traded derivatives started to expand again in the early 2000s. Much of the increased activity was in interest rate futures and options, which are used extensively by banks and by OTC derivatives dealers seeking to hedge against or take advantage of changes in short- and long-term market interest rates.

Table 1.3 shows the notional amount outstanding of exchange-traded financial futures and options contracts at the end of 2007 and 2008.

Overall the figures in Table 1.3 show a decline in 2008 as a result of the credit crunch. This decline continued in early 2009, but trading started to recover later in the year as more confidence returned to the markets. At end-June 2009 the notional amount outstanding on financial futures contracts was about \$19.7 trillion and on option contracts about \$43.8 trillion.

CHAPTER SUMMARY

In finance, a derivative is a product whose value depends on some other underlying asset, such as a commodity or a share or a bond or a foreign currency. Derivative contracts are either traded on organized exchanges, or agreed directly between two parties in the over-the-counter (OTC) market. Exchange-traded contracts are generally standardized but carry a guarantee that the contract will be honoured.

There are three main types of derivative products: forwards and futures, swaps, and options. A forward is a bilateral agreement that one party will deliver an underlying asset to another on a future date at a fixed price. In some cases there is no delivery and the difference between the fixed contract price and the actual market price of the underlying at expiry is paid in cash. Futures are the exchange-traded equivalents of forwards.

A swap is an agreement between two parties to exchange payments on regular dates for an agreed period of time. Each payment leg is calculated on a different basis. In a standard or 'plain vanilla' interest rate swap one leg is based on a fixed rate of interest and the return leg is based on a floating or variable rate of interest. A swap is composed of a series of forward contracts.

The purchaser of an option has the right but not the obligation to buy (call) or to sell (put) an underlying asset at a pre-set price. The other side of the transaction is taken by the writer or seller of the option contract. The purchaser of an option has to pay an up-front sum of money called the premium to the writer of the contract.

Derivatives are used to manage risk, to speculate on the prices of assets and to construct risk-free or arbitrage transactions. The notional value of derivatives contracts outstanding globally amounts to trillions of US dollars.

2

Equity and Currency Forwards

INTRODUCTION

In a **physically delivered** forward contract one party agrees to buy and the other to sell a commodity such as oil or a financial asset such as a share:

- on a specific date in the future;
- at a fixed price that is agreed at the outset.

Some contracts are **cash-settled**. This means that one party pays the other the difference between the fixed price stated in the contract and the actual market value of the underlying commodity or asset on a future date.

Forwards are bilateral over-the-counter (OTC) transactions, and at least one of the parties involved is normally a financial institution. OTC deals are used by corporations, traders and investing institutions. They can be tailored to meet specific requirements. Futures are similar in their economic effects but are standardized contracts traded on organized and regulated exchanges (see Chapters 4 and 5). Forwards potentially involve **counterparty risk** – the risk that the other party may default on its contractual obligations.

Note that throughout this book the term **share** is used to mean an equity security such as an IBM share. In the US the expression 'common stock' is also used. Shares represent a stake in a business, normally carry voting rights, and are paid dividends out of the company's net profits after it has made due payments on its debt.

EQUITY FORWARD CONTRACT

Suppose that a trader agrees today to buy a share in a year's time at a fixed price of \$100. This is a forward purchase, also called a **long forward position**.

The graph in Figure 2.1 shows the trader's potential profits and losses (P&L) on the deal for a range of possible share values at the point of delivery. For example, if the share is worth \$150 in a year then the trader buys it for \$100 through the forward contract and can sell it immediately for a \$50 profit. However, if the share is only worth \$50 the trader is still obliged to buy it for \$100. The loss then is \$50.

The other party to the deal – the counterparty – has agreed to sell the share to the trader in a year for a fixed \$100 price. This is a forward sale, also called a **short forward position**.

Figure 2.2 shows the potential profits and losses on this short position. This assumes that the counterparty is not holding the share and will have to buy it in the spot market in a year to deliver it via the forward contract. If the share costs *less* than \$100 at that point then the counterparty makes a profit from delivering it for \$100. But if the share costs *more* than \$100 in a year the counterparty makes a loss from delivering it via the forward deal.

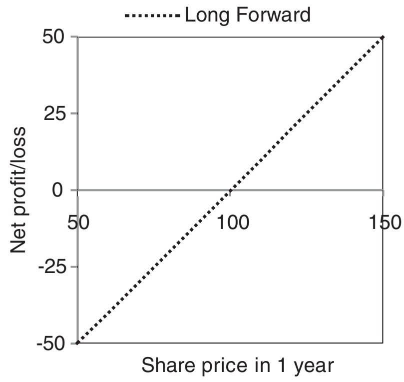

Figure 2.1 Profit and loss on long forward position

THE FORWARD PRICE

A forward contract involves two parties agreeing to buy and to sell an asset on a future date at a fixed price. This rather begs the question: how can they possibly agree on what is a fair or reasonable price for delivery on a date in the future? The standard answer is provided by what is known as a **cash-and-carry** calculation. This is based on the assumption that arbitrage opportunities should not be available in an active and efficient market.

> **Arbitrage Defined**
>
> An arbitrage is a set of deals in which risk-free profits are achieved, because assets are mispriced in the market. Some traders refer to this as a 'free lunch'.

To illustrate the method, suppose that a share is trading for \$100 in the spot or cash market, the market for buying and selling shares for immediate delivery. A derivatives dealer is contacted by a client who would like to buy the share, not today, but in one year, and at a fixed price.

How can the dealer decide on a fair price? He or she could take a view on the level at which the share is most likely to be trading in the future, perhaps by contacting a number of analysts

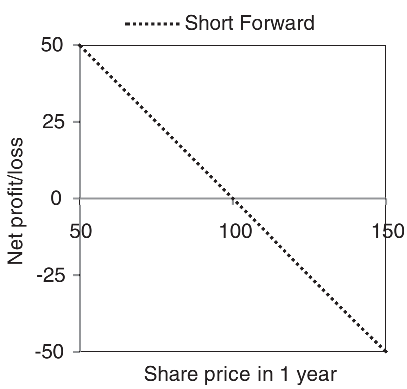

Figure 2.2 Profit and loss on short forward position

Figure 2.3 Cash flows resulting from carrying the share position

or by inspecting charts of its recent price movements. The problem is that this is all highly speculative. If the forward price is set too low the dealer may end up making a loss on the deal.

Establishing the fair forward price

Is there a way of establishing a fair price for the forward contract *without* having to take this risk? The answer is 'yes'. Suppose the one-year interest rate is 10% and that the share is expected to pay a dividend of $5 during the coming year. The dealer can borrow $100, buy the share in the spot market, and then hold or 'carry' it for one year so that it is available for delivery to the client at that point. In one year's time the dealer will have to repay the $100 loan plus $10 interest. However the funding cost is partly offset by the $5 dividend received.

Figure 2.3 shows the cash flows resulting from 'carrying' the share in order to deliver it in one year's time to the client. The break-even price for delivering the share at that point (ignoring any transaction costs) is $105. A receipt of $105 arising from the delivery would exactly match the $105 outflow of cash shown in Figure 2.3.

Components of the forward price

The forward price has two components: the $100 cost of buying the share in the cash market, and the net cost of carrying the position to deliver the share in the future. The carry cost in turn has two components: the loan interest (in this case $10) minus the dividends received on the share (in this case $5).

$$\text{Break-even forward price} = \text{Cash} + \text{Net cost of carry}$$
$$\text{Net cost of carry} = \$10 - \$5 = \$5$$
$$\text{Break-even forward price} = \$100 + \$5 = \$105$$

Strictly speaking the net carry cost is likely to be slightly less than $5 because dividend payments received during the course of the year can be reinvested.

THE FORWARD PRICE AND ARBITRAGE OPPORTUNITIES

Suppose the dealer in the previous section could enter into a forward contract agreeing to sell the share to a client in one year for *more* than $105, say for $120. The dealer promptly agrees the deal, and at the same time:

- borrows $100 and buys the share in the cash market;
- holds the share for one year, earning a $5 dividend.

After one year the dealer repays the loan plus interest, totalling $110. Adding back the $5 dividend, the net cash outflow is $105. If the dealer is locked into a forward contract in which the share can be sold at that point for $120 then the dealer will make an overall profit of $15. In theory this is risk-free (an arbitrage), although in practice there may be a concern over whether the counterparty on the forward contract may default on the deal. If this risk can be insured against for less than $15 then the dealer really has achieved an arbitrage profit.

Closing the gap

In the real world ‘free lunches’ of the kind just described should not persist for long. Traders would rush in to sell the share forward for $120, simultaneously buying it in the cash market for $100 funded by borrowings. The effect would be to push the forward price back towards the level at which the arbitrage opportunity disappears (it may also pull up the cash price of the share).

What keeps the forward price ‘honest’, i.e. at or around fair value as calculated by the cash-and-carry method (in this case $105) is the potential for arbitrage profits.

If the forward price in the market is *below* fair value, traders will buy forward contracts and short the share. In practice, shorting is achieved by borrowing the stock with a promise to return it to the original owner at a later date. It is then sold in the cash market and the proceeds put on deposit to earn interest. The effect of traders buying underpriced forward contracts and shorting the underlying share will be to pull the forward price back up towards its theoretical or fair value.

In fact the forward price can diverge to some extent from the theoretical value derived from a simple cash-and-carry calculation. This is because of transaction costs. Buying and holding a share involves paying brokerage and other fees. Maintaining a short position involves borrowing shares and paying fees to the lender.

The forward price and commodities

How does the cash-and-carry method work with forward contracts on *nonfinancial* assets? It is commonly applied to gold and silver, which are held for investment purposes. However it has to be used with caution in the case of commodities that are held primarily for consumption.

With some commodities (such as fresh fruit) it simply does not apply at all, since storage for delivery on a future date is not practical. In other cases it has limited application. Oil is a case in point. Quite often the spot price of oil is *higher* than the forward or futures price in the market, although the simple cash-and-carry method suggests that the reverse should hold. One explanation is that large consumers are prepared to pay a premium to buy oil in the spot market, so that they can hold it in inventory and ensure continuity in supply.

THE FORWARD PRICE AND THE EXPECTED PAYOUT

It is common to think of the forward price of an asset as the **expected future spot price** on the delivery date. In other words, the forward price is seen as a prediction of what the asset price will be in the future. This is based on the available evidence at the time and is subject to later revision as new evidence emerges.

There is at least one reason to believe this idea: if forward prices *were* biased or skewed in some way it would be possible to construct profitable arbitrage strategies. Suppose that forward prices have a systematic tendency to underestimate the actual spot prices on future dates. Then a trader who consistently buys forward contracts will tend to make money on deals more often than he or she loses money. This would amount to a money-making scheme.

Bias in Forward and Futures Prices

It seems unlikely that there is 'easy money' to be made trading forwards or futures (their exchange-traded equivalents). However following arguments made by the economist J. M. Keynes, it has been suggested that this phenomenon can exist, and that the profits attract speculators into the market. There has been a lot of research into whether or not forward and futures prices are biased. The results are still inconclusive.

If we *do* assume that the forward price of an asset is the expected spot price on the future delivery date, this has important implications. It is an expectation based on currently available evidence. As a forward contract moves towards the point of delivery new information will be received, changing the expectation. If this is random information, some of it will be 'good news' for the price of the underlying asset and some 'bad news'.

There is thus a chance that at the point of delivery the underlying will actually be above the value that was expected when the forward contract was initially agreed, but there is also a chance that it will be below that value. If the new information is indeed random we could say that there is a 50:50 chance that the spot price will be above (or below) that initially expected value. Therefore the chance of making or losing money on a forward contract is about 50:50 and the *average* payout from the deal is approximately zero.

Expected payout from a forward

This result is actually suggested by Figures 2.1 and 2.2. The forward delivery price was $100. Assume that this is the expected spot price at the point of delivery, and there is a 50:50 chance that the underlying will be above (or below) that value when delivery takes place. Then the buyer of the forward has a 50% chance of making a profit and a 50% chance of losing money. The average payout (averaging out potential profits and losses) is zero.

The seller of the forward also has an average payout of zero. It follows from this that neither party should pay a premium to the other at the outset for the forward contract, since there is no initial advantage to either side. Note that the situation is completely different with options. The buyer of an option pays an up-front premium to the writer precisely because the buyer *does* have an initial advantage – the right to exercise the contract in favourable circumstances, but otherwise to let it expire.

FOREIGN EXCHANGE FORWARDS

A spot foreign exchange (FX) deal is an agreement between two parties to exchange two currencies at a fixed rate in (normally) two business days' time. The notable exception is for deals involving the US dollar and the Canadian dollar, in which case the spot date is one business day after the trade has been agreed. The day when the two currencies are actually exchanged is called the **value date**. A spot deal is said to be 'for value spot'.

An **outright forward** foreign exchange deal is:

- a firm and binding commitment between two parties;
- to exchange two currencies;
- at an agreed rate;
- on a future value date that is later than spot.

The two currencies are not actually exchanged until the value date is reached, but the rate is agreed on the trade date.

Outright forwards are used extensively by companies that have to make payments or are due to receive cash flows in foreign currencies on future dates. A company can agree a forward deal with a bank and lock into a known foreign exchange rate, thus eliminating the risk of losses resulting from adverse exchange rate fluctuations. The other side of the coin, of course, is that the contract must be honoured even if the company could subsequently obtain a better rate in the spot market. In effect the company surrenders any potential gains resulting from favourable movements in currency exchange rates in return for certainty.

The forward FX rate

As we will see, outright forward exchange rates quoted by banks are determined by the spot rate and the relative interest rates in the two currencies.

Traders talk about this in terms of the relative **carry cost** of holding positions in the two currencies. In effect, the forward FX rate is established through a hedging or arbitrage argument – what it costs a bank to cover the risks involved in entering into an outright forward deal. If a forward rate moves out of alignment with its fair or theoretical value, then this creates the potential for a risk-free or arbitrage profit.

MANAGING CURRENCY RISK

This section illustrates the practical applications of outright forwards with a short example. The case is that of a US company which has exported goods to an importer in the UK. The British firm will pay for the goods in pounds sterling (code GBP). The agreed sum is GBP 10 million and the payment is due in two months' time.

The current spot rate is GBP/USD 1.5, i.e. one pound buys 1.5 US dollars. If the invoice was due for immediate settlement, then the US company could sell the pounds on the spot market and receive $15 million. However the payment is due in the future. If the pound weakens over the next two months, the US firm will end up with fewer dollars, potentially eliminating its profit margin from the export deal.

To complete the picture, we will suppose that the US company incurs total costs of $13.5 million on the export deal and aims to achieve a margin over those costs of at least 10%.

Profits and losses on the export deal

Table 2.1 shows a range of possible spot rates in two months' time, when the US firm will be paid the GBP 10 million. The second column calculates the amount of dollars the company would receive for selling those pounds at that spot rate. The third column shows its profit or loss on the export transaction assuming that its dollar costs on the deal are $13.5 million. The final column calculates the margin achieved over the dollar costs.

Table 2.1 Profit and profit margin for different spot exchange rates

Spot rate	Received ($)	Net profit or loss ($)	Margin over costs (%)
1.3	13 000 000	−500 000	−4
1.4	14 000 000	500 000	4
1.5	15 000 000	1 500 000	11
1.6	16 000 000	2 500 000	19
1.7	17 000 000	3 500 000	26

If the spot exchange rate in two months' time is 1.5 then the US exporter will receive $15 million from selling the GBP 10 million. The profit in dollars is $1.5 million and the margin achieved (over the dollar costs incurred) is 11%. On the other hand, if the spot rate turns out to be 1.4 then the company will receive only $14 million for selling the pounds. The profit then is $500 000 and the margin well below target at 4%.

There is a chance, of course, that the pound might *strengthen* over the next two months. If it firms up to (say) 1.6 dollars then the US exporter's profit margin is a healthy 19%. The management might be tempted by this, but if so they are simply speculating. Does the company have any special expertise in forecasting currency exchange rates? Many firms believe that they do not, and actively hedge foreign currency exposures.

The next section explores how the US exporter could manage its currency risks using a forward FX deal.

HEDGING WITH AN OUTRIGHT FORWARD FX DEAL

The US company approaches its relationship bankers and enters into a two-month outright forward FX deal. The agreed rate of exchange is GBP/USD 1.4926. The deal is constructed such that in two months' time:

- the company will pay the GBP 10 million it is due to receive from its client over to the bank;
- in return for the pounds the bank will pay the company $14.926 million.

The currency amounts are fixed, regardless of what the spot rate in the market happens to be at the point of exchange. The forward contract is a legal obligation and must be fulfilled by both parties.

Table 2.2 compares the results for the US company of hedging its currency exposure using the FX forward deal and of leaving the risk uncovered.

Showing the results in a graph

The results from the table are graphed in Figure 2.4. The solid line shows the dollars the company will receive if it leaves the currency exposure unhedged. The dotted line shows the fixed amount of dollars ($14.926 million) it will receive if it agrees the forward FX deal. Its total costs amount to $13.5 million, so by entering the forward deal it can achieve a margin over cost of 10.6%, above its 10% target. The hedge has achieved its purpose.

Table 2.2 Dollars received by US exporter unhedged and hedged

(1) Spot rate	(2) Received at spot rate ($)	(3) Received at forward rate ($)	(4) Difference ($)
1.3	13 000 000	14 926 000	−1 926 000
1.4	14 000 000	14 926 000	−926 000
1.5	15 000 000	14 926 000	74 000
1.6	16 000 000	14 926 000	1 074 000
1.7	17 000 000	14 926 000	2 074 000

In Table 2.2:
Column (1) shows a range of possible spot rates in two months' time.
Column (2) indicates what would happen if the company left its currency exposure unhedged; it calculates the dollars received from selling the GBP 10 million due at that point at the spot rate in column (1).
Column (3) shows that if the forward deal is agreed at a rate of GBP/USD 1.4926 the US company will always receive exactly $14.926 million for its pounds.
Column (4) calculates the difference between columns (2) and (3); for example, if the spot rate in two months is 1.3, the company would lose $1.926 million as a result of not having entered into the forward FX deal.

THE FORWARD FOREIGN EXCHANGE RATE

The theoretical or fair rate for entering into an outright forward FX deal can be established using the spot exchange rate and the interest rates on the two currencies involved. In fact, it is a **cash-and-carry** calculation.

In the previous section the US company hedged its currency exposure by selling pounds for dollars at a forward rate of 1.4926. Is this a fair rate or not? To help answer this question, suppose the following additional market information is available.

- GBP/USD spot foreign exchange rate = 1.5.
- US dollar interest rate = 3% p.a. = 0.5% for two months.
- Sterling interest rate = 6% p.a. = 1% for two months.

To simplify matters we will assume here that interest rates in the market for borrowing and lending funds are exactly the same; and that the spot exchange rates for buying and for selling pounds are also exactly the same. In practice, money dealers quote different borrowing and

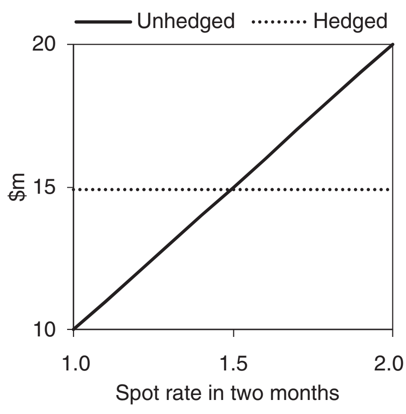

Figure 2.4 Dollars received hedged and unhedged

Figure 2.5 Result of investing pounds and dollars for two months

lending rates; and currency traders quote different bid (buy) and ask (sell) rates. The difference between the two rates is called the **dealer's spread**.

According to the data available, one pound equals 1.5 US dollars on the spot market. Pounds can be invested for two months at an interest rate of 1% for the period. Dollars can be invested at a period rate of 0.5%. Figure 2.5 illustrates the results of investing GBP 100 and \$150 respectively for two months at those interest rates.

In the spot market GBP 100 equals \$150. However 100 pounds invested today would grow to GBP 101 in two months' time. \$150 would grow at a somewhat slower rate because the dollar interest rate is lower. In two months it would be worth \$150.75. This tells us the value of a pound against the US dollar in two months' time.

$$\text{GBP } 101 = \text{USD } 150.75$$
$$\text{GBP } 1 = \frac{150.75}{101} = \text{USD } 1.4926$$

So the theoretical two-month forward rate is GBP/USD 1.4926.

THE FORWARD FX RATE AND ARBITRAGE OPPORTUNITIES

Forward deals agreed in the market must be contracted at or around the fair rate established by the cash-and-carry method, otherwise arbitrage opportunities are created.

To see why this is so, this section uses the same numbers from the previous section. This calculated a theoretical two-month forward rate of GBP/USD 1.4926.

Suppose that dealers are prepared to enter into deals in which the two currencies will be exchanged in two months' time at a different rate, say at the current spot rate of GBP/USD 1.5. Then an arbitrageur could step in and set up the following deals today.

- Borrow \$150 for two months at a period interest rate of 0.5%.
- Sell the \$150 in the spot foreign exchange market and receive GBP 100.
- Deposit the GBP 100 for two months at a period interest rate of 1%. At maturity the sterling deposit, including interest, will have grown to GBP 101.

At the same time, the arbitrageur would enter into an outright forward FX contract agreeing to sell the GBP 101 due in two months' time for dollars at a rate of 1.5. After two months the arbitrageur would unwind all the transactions as follows:

- Repay the \$150 borrowed plus interest, which comes to \$150.75.
- Receive back the GBP 100 deposited, which with 1% interest equals GBP 101.
- Sell the GBP 101 for dollars under the terms of the forward contract and receive $101 \times 1.5 = \$151.5$.

As a result the arbitrageur would make a risk-free profit of $151.5 − $150.75 = $0.75, irrespective of what had happened to exchange rates in the meantime. If the transaction was based on $15 million rather than $150, then the profit would be $75 000.

No Arbitrage at Fair Forward Rate

The profit calculated above is based on the assumption that pounds can be sold for delivery in two months' time at GBP 1 = $1.5. If the exchange rate was the fair rate of 1.4926 the arbitrage profit would disappear.

This simple example demonstrates why forward FX deals are transacted at or around the theoretical fair value. If they are not, then traders will quickly rush in to make arbitrage deals, and the actual market rate will move back towards its theoretical or equilibrium value. In practice, dealing spreads and transaction costs complicate the story a little but the general principle still holds.

FORWARD POINTS

In the above example it is noticeable that the theoretical forward FX rate of 1.4926 is *lower* than the spot rate of 1.5. Market practitioners would say that the pound is at a **discount** relative to the dollar for delivery in two months. In other words, it buys fewer US dollars compared to the spot rate. This results from the different interest rates in the two currencies. The sterling rate was assumed to be 6% p.a. and the dollar rate 3% p.a.

The situation can be explained in economic terms. There are a number of reasons why investors might demand a higher return for holding sterling compared to US dollar investments, and two main possibilities may be:

- sterling-denominated assets are riskier;
- investors believe that the real value of sterling assets will be eroded at a faster rate because the pound has a higher rate of inflation compared to the US dollar.

There could be other reasons. For example, international investors might place a lower level of trust in the conduct of monetary policy in the UK.

It is clear, however, that concerns about inflation are major factors. If investors anticipate that the pound will suffer from higher inflation than the US dollar they will demand higher returns on sterling-denominated assets in compensation. Also, the pound will trade at a discount against the dollar for forward delivery compared to spot deals since its real value in terms of purchasing power is eroding at a faster rate.

Calculating forward points

Market practitioners often quote currency forwards in terms of the discount or premium in **forward points** compared to the spot rate. For example:

- Spot rate = 1.5000
- Forward rate = 1.4926
- Discount = −0.0074 = 74 points

In the ‘cable’ market (the market for deals between the dollar and sterling) one point or **pip** represents \$0.0001 per pound. So a discount of 74 points equals \$0.0074 per pound sterling.

FX SWAPS

An FX swap is the combination of a foreign exchange deal (normally for value spot) and a later-dated outright forward deal in the opposite direction. Both deals are made with the same counterparty, and one of the currency amounts in the deal is normally kept constant. If the first leg of the swap is for a value date later than spot, then the transaction is called a **forward-forward swap**.

The following example uses the same spot rate and interest rates from previous sections.

- GBP/USD spot exchange rate = 1.5
- Sterling interest rate = 6% p.a.
- US dollar interest rate = 3% p.a.
- GBP/USD two-month forward exchange rate = 1.4926

Suppose that a customer contacts a bank and agrees an FX swap transaction with the following terms.

- **Spot Leg**. The customer sells the bank GBP 10 million and receives in return \$15 million (at the spot rate).
- **Forward Leg**. In two months’ time the customer is repaid the GBP 10 million by the bank and pays in return \$14.926 million (at the two-month forward exchange rate).

Here the customer only pays back \$14.926 million on the forward leg, despite having received \$15 million spot. The difference between the two amounts is \$74 000.

Why is there a difference? It is determined by the interest rate differential between the two currencies. For the period of the FX swap the customer is moving out of a higher return currency (the pound) and into a lower yield currency (the dollar) and must be compensated. In effect, the \$74 000 is the cost of the **interest rate differential** between the two currencies expressed in US dollars (the sterling amount is kept constant).

The cash flows resulting from the FX swap transaction (viewed from the customer’s perspective) are illustrated in Figure 2.6.

By comparison, if a client enters into an FX swap with a bank and moves from a *lower to a higher* interest rate currency, it will pay back *more* of that higher rate currency on the forward leg than it receives on the spot leg of the swap (assuming the lower interest rate currency amount is held constant). The client has to compensate the bank for receiving the benefit of moving into the higher interest currency over the life of the FX swap deal.

Figure 2.6 FX swap cash flows

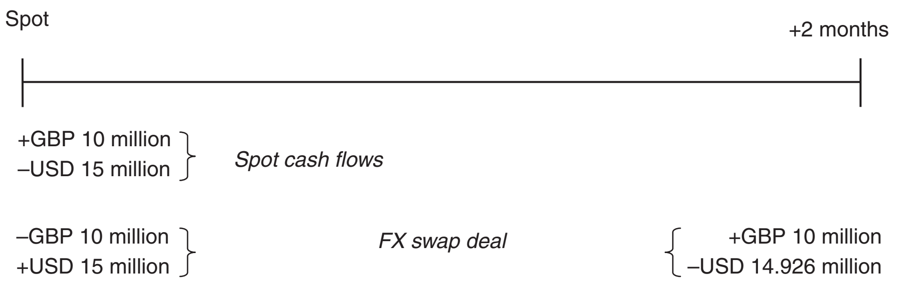

Figure 2.7 Using an FX swap to manage a bank's cash flows

APPLICATIONS OF FX SWAPS

Pension fund managers can use an FX swap to transfer cash into a foreign currency for a set period of time, to increase diversification and boost returns by investing in foreign shares and bonds. The foreign currency purchased on the spot leg of the swap will be exchanged back into domestic currency at a fixed rate on the forward leg of the swap. This helps to manage the currency risks associated with purchasing overseas assets.

FX swaps are also used by banks to manage the cash flows resulting from currency and money market transactions.

For example, the swap illustrated in Figure 2.6 might be entered into by a commercial bank which has to pay $15 million spot. It notices that it is also receiving GBP 10 million on that day. Rather than borrowing the dollars, it sells its excess pounds for dollars in the spot leg of the FX swap, thereby covering its cash flows on the spot date. The net result of the FX swap is to move the bank's sterling and dollar positions forward in time by two months, without actually having to borrow or lend out funds on the money market.

Effects of the FX swap deal

The effect is illustrated in Figure 2.7. This can be a very efficient technique since, unlike actually borrowing and lending money, the FX swap does not use the bank's balance sheet. It is structured as a spot deal combined with a commitment to re-exchange the two currencies in two months' time.

CHAPTER SUMMARY

A forward contract is an agreement between two parties to deliver a commodity or a financial asset on a future date at a predetermined price. Some contracts are settled in cash.

In many cases the fair or theoretical forward price can be determined through a cash-and-carry calculation. This is based on what it would cost the seller of the forward to cover his or her risks on the deal by buying the asset in the cash market and holding or 'carrying' it to deliver on the date specified in the forward contract.

If it is possible to trade a forward contract above or below the fair price then (subject to transaction costs) it may be possible to construct profitable arbitrage transactions. At fair value the average or expected payout from a forward is zero; therefore, unlike an option, neither party to the deal owes the other an initial premium. With perishable commodities that cannot be stored or shorted the cash-and-carry method does not apply.

Outright forward foreign exchange deals are used by investors, banks and corporations to hedge against the risks posed by fluctuations in currency exchange rates. The fair forward rate is determined by the spot rate and the interest rates in the two currencies.

An FX swap is the combination of a foreign exchange deal and an outright forward deal with a later value date in the opposite direction. Normally one currency amount is held constant. FX swaps are used by banks to manage their cash flows in different currencies, and by fund managers who wish to hedge the risks associated with investing in assets denominated in foreign currencies.

3
Forward Rate Agreements

INTRODUCTION

A forward rate agreement (FRA) is a bilateral contract fixing the rate of interest applying to a notional principal amount of money for an agreed future time period. One party is said to be the FRA buyer and the other the seller. However the notional principal never changes hands. It is simply used to calculate the **settlement sum**.

- **FRA Buyer**. The buyer is paid a settlement sum by the seller if the reference or benchmark interest rate for the contract period turns out to be above that agreed in the contract.
- **FRA Seller**. The seller is paid a settlement sum by the buyer if the benchmark interest rate turns out to be below the contractual rate.

An FRA is a derivative instrument because its value is derived from spot or cash market interest rates, that is, the interest rates on deposits and loans starting now rather than in the future. This is illustrated in this chapter.

Users of FRAs

The natural buyers of FRAs are corporate borrowers who wish to hedge against rising interest rates. Money market investors who wish to protect against declining interest rates are natural sellers of FRAs.

FRAs are similar to exchange-traded interest rate futures contracts (Chapter 5) except that FRAs are over-the-counter (OTC) deals. As we have seen, an OTC derivative is a legal and binding agreement made directly between two parties. It cannot be freely traded and carries a potential counterparty risk – the risk that the other party might fail to fulfil its obligations. On the other hand, the terms of the contract are flexible and can easily be customized. Nowadays FRAs are dealt by banks in a wide range of currencies and contract periods.

FRA CASE STUDY: CORPORATE BORROWER

The case explored in this section is that of a corporate borrower with an outstanding \$100 million loan. The interest rate on the loan is refixed twice a year at six-month dollar LIBOR plus a margin of 100 basis points (1%) p.a. Six-month dollar LIBOR is the London interbank offered rate for dollar loans maturing in six months' time.

LIBOR Defined

LIBOR is the key benchmark interest rate set every London business day by the British Bankers' Association (BBA). Because commercial banks fund themselves at or around LIBOR, they lend money to customers at LIBOR plus a margin, which earns a profit and provides some protection against the risk of default. LIBOR is quoted for a variety of major currencies (including the US dollar) and a range of maturity periods.

Note that for simplicity the following example ignores the effects of the day-counting method used to calculate LIBOR interest payments. The method is explained in *An Introduction to International Capital Markets*, by the current author, also published in the Wiley Finance series. This also sets out the FRA settlement formula in full.

In this case study the company has just fixed its borrowing rate for the next six-month period. However, the company's finance officer is concerned that interest rates for the *subsequent* time period might turn out to be much higher. This could affect the company's profits, and potentially its share price. To protect against this risk the finance officer decides to buy an FRA from a dealer. The terms of the contract are set out in Table 3.1.

The company will be paid a settlement sum by the FRA dealer if six-month dollar LIBOR for the contract period turns out to be *above* the FRA contractual rate of 5% p.a. If LIBOR is fixed *below* 5% p.a. then the company will have to make a settlement payment to the dealer. Settlement will be based on a notional principal of \$100 million. Both parties, the company and the dealer, sign the FRA contract, which is a legal and binding commitment. Typically deals are based on outline legal terms drawn up by the British Bankers' Association.

The FRA settlement

In six months' time the *actual* BBA six-month dollar LIBOR rate for the period covered by the FRA contract will be known to both parties. It will be announced on market information systems such as Reuters or Bloomberg. Suppose that the dollar LIBOR rate for the period gets set at 7% p.a. Then the dealer that sold the FRA will have to compensate the company (the buyer) since LIBOR is above the fixed contractual rate of 5% p.a.

$$\text{Settlement sum} = \$100 \text{ million} \times \frac{7\% - 5\%}{2} = \$1 \text{ million}$$

Note that in this calculation the interest rates are expressed per annum but the FRA actually covers a six-month time period. This is why the difference between the actual LIBOR rate (7%) and the FRA rate (5%) is halved.

Effective borrowing rate

The company can then use the settlement sum to partially offset the interest payment it has to make on its borrowings. It has a \$100 million bank loan on which it pays LIBOR plus 1% p.a. If LIBOR for the period is fixed at 7% p.a. then its loan rate for the period will be set at 8% p.a. Subtracting the settlement sum received on the FRA, however, its payments for the period

Table 3.1 Forward rate agreement terms

Notional principal:	\$100 million
Deal type:	Client buys FRA
Contract rate:	5% p.a.
Contract period:	A future six-month period starting in six months' time
Reference rate:	Six-month US dollar LIBOR

are as follows (again ignoring the complexities of day-counts).

$$\text{Interest paid on loan} = \$100 \text{ million} \times \frac{8\%}{2} = \$4 \text{ million}$$
$$Subtract: \text{ Settlement sum received on FRA} = \$1 \text{ million}$$
$$\text{Net cost of borrowing} = \$3 \text{ million}$$
$$\text{Effective borrowing rate} = \frac{\$3 \text{ million}}{\$100 \text{ million}} = 3\% \text{ for six months} = 6\% \text{ p.a.}$$

RESULTS OF THE FRA HEDGE

By entering into the FRA the company has locked into an interest rate of 6% p.a. for the period covered by the contract.

This is demonstrated in Table 3.2. The first column shows a range of possible rates at which dollar LIBOR might be set by the BBA for the contract period. The second column calculates the company's borrowing rate on its loan at LIBOR + 1%. The third column combines the interest payment due on the loan with the FRA settlement sum. The final column shows the effective borrowing rate per annum i.e. including the FRA settlement.

The results in Table 3.2 can be illustrated by taking a few examples:

- **LIBOR = 3% p.a.** The company's borrowing rate on its loan is 4% p.a. The interest cost for the period is therefore \$2 million. LIBOR is 2% p.a. below the FRA contract rate of 5% p.a. Therefore the company has to *pay* the FRA dealer half of 2% of \$100 million (for a six-month period) which comes to \$1 million. Its net borrowing cost is now \$3 million, so effectively it is paying an annualized rate of 6% p.a. for the period.
- **LIBOR = 7% p.a.** The borrowing rate on the loan is 8% p.a. The interest cost for six months is therefore \$4 million. However this time a settlement sum of \$1 million is *received* from the FRA dealer. The company's net borrowing cost is therefore \$3 million, and so the effective interest rate for the period is 6% p.a.

The FRA hedge illustrated

The graph in Figure 3.1 illustrates the results from Table 3.2. The horizontal axis shows a range of possible LIBOR rates for the future time period covered by the FRA deal. The dotted line shows the company's effective rate of borrowing for the period if it buys the FRA. The solid line shows what the borrowing rate would be if it does *not* purchase the FRA, i.e. if the company leaves the interest rate exposure unhedged.

Table 3.2 Effects of the FRA hedge

LIBOR setting (% p.a.)	Borrowing rate (% p.a.)	Net cost ($m)	Effective rate (% p.a.)
3.0	4.0	3.0	6.0
4.0	5.0	3.0	6.0
5.0	6.0	3.0	6.0
6.0	7.0	3.0	6.0
7.0	8.0	3.0	6.0

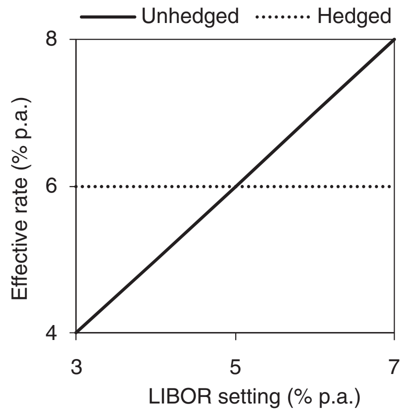

Figure 3.1 Graph of FRA hedge and unhedged borrowing

If it buys the FRA the company is locked into a funding rate for the period of 6% p.a. It is protected against increases in interest rates for that period. By the same token, however, it cannot benefit from a *decline* in interest rates. The company may be prepared to take this risk in return for certainty. If it fixes its borrowing cost it may be easier to plan its business operations, as one source of uncertainty has been eliminated. Hedging against interest rate risk may also help to reduce the volatility of its earnings, and potentially boost the share price.

The FRA contract period

In dealers' jargon the FRA contract explored in this case covers a '6v12' period, i.e. a period of time starting in six months and ending in 12 months.

Note that interest payments are normally made *in arrears*, which in this case would be at the 12-month point. However, the settlement sum on an FRA is usually paid *up-front*, when the LIBOR rate for the contract period is fixed by the BBA. In this example the FRA settlement would actually take place at the six-month point, and be discounted or reduced to reflect this fact. Payment up-front helps to reduce credit risk. Both parties know what is owed after the LIBOR setting, and any delay in payment increases the risk of default.

THE FRA AS TWO PAYMENT LEGS

Another way to look at the FRA is as a deal with two different payment legs. This is shown in Figure 3.2.

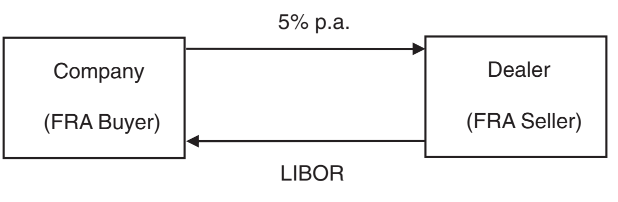

Figure 3.2 The FRA as two separate payment legs

Seen in this way, the FRA is a deal in which:

- the company pays the dealer a rate of 5% p.a. applied to $100 million for the six-month contract period;
- the dealer, in return, pays the company the *actual* LIBOR rate for that period applied to $100 million;
- the amounts from each leg are netted out and one side makes a cash settlement payment to the other.

For example, suppose six-month dollar LIBOR for the contract period is set at 7% p.a. Settlement is as follows:

- the company owes the dealer $100 million x 5% x 1/2 = $2.5 million;
- the dealer owes $100 million x 7% x 1/2 = $3.5 million;
- netted out, the dealer owes the company $1 million.

As discussed above, the settlement sum is normally paid up-front rather than in arrears so the $1 million payment would be reduced in proportion.

Net position with FRA hedge

Figure 3.3 shows the FRA agreement the company has entered into, along with the underlying loan it was seeking to hedge. It has achieved an annualized net cost of borrowing for the contract period equal to:

$$\text{LIBOR} + 1\% - \text{LIBOR} + 5\% = 6\%$$

An FRA is a type of mini-interest rate swap (see Chapter 6). The main differences are that in an interest rate swap there is a *series* of payments on future dates, not just one; and the payments are normally made in arrears. The diagrams used to explain the structure and applications of interest rate swap deals look very much like Figure 3.3.

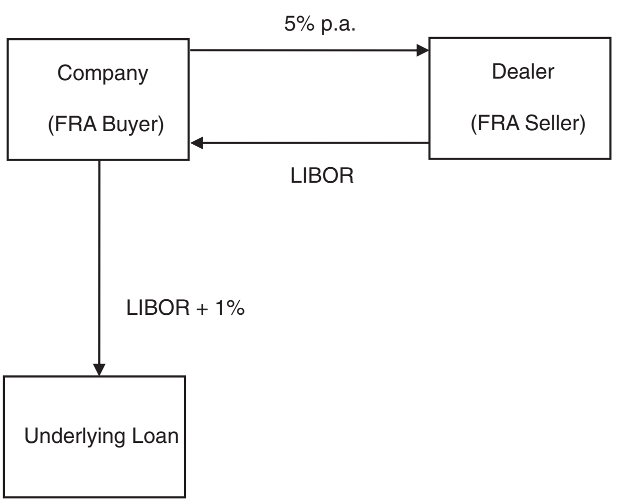

Figure 3.3 Loan plus FRA

DEALING IN FRAs

The dealer in the above case study has sold an FRA covering a period of time starting in six months and ending 12 months after the start date. The forward interest rate agreed is 5% p.a. If this is the only deal on the trading book then the dealer has an exposure to rising interest rates. If dollar LIBOR is set above 5% p.a., the dealer will have to make a cash settlement payment to the buyer of the FRA.

The dealer may have a view that interest rates will fall, and may be quite content to assume this risk. If the actual LIBOR rate at settlement is set below 5% p.a. the dealer will be paid a settlement sum by the buyer. But if the dealer does not have a properly considered view on the future direction of interest rates, then it would be better to hedge or cover the risk.

One way to do this is to use the exchange-traded equivalent of an FRA, an **interest rate futures** contract (see Chapter 5). Another approach would be for the dealer to match the sale of an FRA with an offsetting purchase, the effect of which is illustrated in Figure 3.4.

The dealer's overall position

As before, the dealer has sold a 6v12 month FRA to the company. This time it has also *purchased* an FRA covering the same future time period and with the same notional. The client for the second deal is a money manager concerned about falling interest rates, which would adversely affect the returns made by the fund.

The rate agreed on this second FRA deal is 4.95%. The money manager will receive compensation on this FRA contract if LIBOR for the contract period is set below 4.95%. Otherwise the FRA dealer will be compensated.

FRA bid and ask rates

The rate of 4.95% is the dealer's **bid rate**, the rate at which he or she buys FRAs for the future time period 6v12. The rate of 5% p.a. is the dealer's **offer or ask rate**.

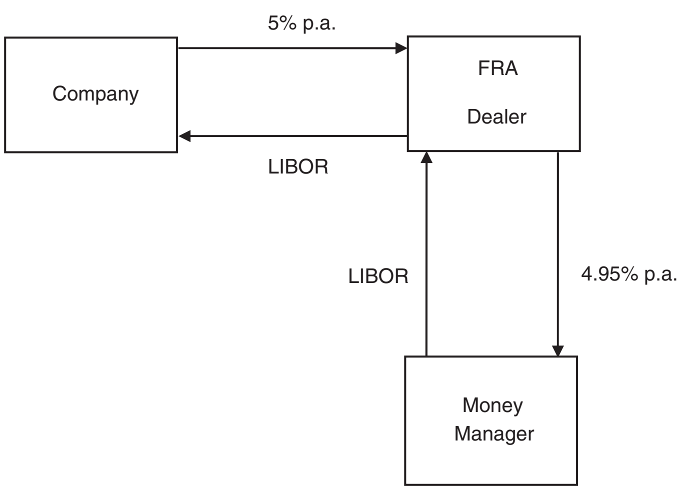

Figure 3.4 Dealer sells and buys offsetting FRAs

The difference – five basis points or 0.05% – is the dealer's spread. The spread exists partly to enable the dealer to make a profit, but it also helps to provide some protection against volatile short-term interest rates. A dealer will normally be prepared to sell or to buy an FRA without having an exactly offsetting deal already in place. However this exposes the dealer to interest rate risk until such time as an offsetting deal is agreed or an effective hedge can be put in place.

FORWARD INTEREST RATES

How can the two parties to an FRA decide what is a fair forward interest rate? One answer to this question is to look at arbitrage relationships. The existence of FRAs allows market participants to lock into rates for borrowing and for reinvesting money on future dates. For example, a trader could carry out the following transactions today.

- Borrow dollars for one year at a fixed interest rate.
- Deposit those funds for six months at a fixed interest rate.
- Lock into a rate for reinvesting the proceeds due from the deposit in six months' time for a further six months by selling a 6v12 month FRA.

If the returns from investing and reinvesting the dollars exceed the cost of borrowing the money in the first instance, then the trader has constructed a 'free lunch' trade – an arbitrage transaction. In an efficient financial market such a situation should not persist for long. The assumption that no arbitrage is possible can be used to calculate the fair or theoretical forward interest rate at which a 6v12-month FRA should be sold on the market, based on the market rates for borrowing and lending funds for 12 months and six months respectively.

FRA Rates and Interest Rate Futures

In practice the contract rates on FRAs are normally established through the prices at which the relevant short-term interest rate futures contracts are traded on the exchange (discussed in detail in Chapter 5).

Because interest rate futures contracts in major currencies such as dollars, sterling and euros are actively traded by many market participants, they are often taken as establishing the market's consensus expectations on future interest rates in those currencies. They are used to price over-the-counter products such as FRAs and interest rate swaps, instruments whose values depend on expected interest rates for future time periods.

CHAPTER SUMMARY

A forward rate agreement (FRA) is a contract agreed between two parties fixing the rate of interest that will be applied to a notional amount of money for a future time period. The notional is not exchanged; there is instead a cash settlement payment based on the difference between the rate agreed in the contract and the actual market interest rate for the period, as established by a benchmark such as LIBOR. The buyer of the FRA is compensated if LIBOR is found to be above the contractual rate. Otherwise the buyer compensates the seller.

FRAs are often purchased by companies concerned about rising interest rates, and sold by money managers who are worried about falling reinvestment rates. Dealers quote FRA bid (buy) and ask (sell) rates for a range of currencies and contract periods. The fair or theoretical contractual rate on an FRA can be established from spot market interest rates. In practice, though, the rates for contracts in a major currency are normally based on the rates implied in short-term interest rate futures, which are the exchange-traded equivalents of FRAs.

4
Commodity and Bond Futures

INTRODUCTION

A futures contract is an agreement made through an organized exchange to buy or to sell a fixed amount of an underlying commodity or financial asset on a future date (or within a range of dates) at an agreed price. Some contracts result in the **physical delivery** of the underlying. Others are **cash-settled** which means that the difference between the agreed price and the market price of the underlying on the future date is paid in cash.

Futures are either traded by open outcry in trading pits in the form of an auction, or on electronic screen-based systems. The merged Chicago exchanges CME and CBOT currently (2010) operate both methods in tandem. Other exchanges such as LIFFE in London (now part of NYSE Euronext) and Eurex (the Swiss-German market) are wholly electronic. On an exchange traders representing member organizations transact orders for their own firm and also act on behalf of clients including banks, corporations, money managers and private individuals.

Main Functions of a Futures Exchange

The exchange does not buy or sell contracts on its own account. Its main functions are to facilitate trading, to monitor conduct and ensure that the rules are adhered to, and to publish the prices at which trades are agreed. Overall, the exchange enables **price discovery** i.e. it helps buyers and sellers to come together to agree a price at which both sides are willing to trade.

When a trade is agreed the details are entered into the exchange's price reporting system. Data from the exchanges are published throughout the world on websites and news services such as Reuters and Bloomberg. Nowadays, deals made in trading pits on exchanges are normally recorded on hand-held electronic devices.

Because a futures contract is simply a promise to fulfil an obligation on a future date, a trader can sell contracts without first buying contracts. A trader who sells more contracts than he or she has bought has a **short futures position**. A trader who buys more contracts than he or she has sold has a **long futures position**.

THE MARGINING SYSTEM AND THE CLEARING HOUSE

Unlike over-the-counter (OTC) contracts, futures are essentially standardized products, which encourages active and liquid trading. On the other hand, the **clearing house** associated with the exchange protects against credit risk by guaranteeing the performance of all trades made on an exchange. Trades are registered with the clearing house by major financial institutions called clearing members (see Chapter 20).

To buy or sell futures, a trader who is not a member of an exchange has to have a margin account with a broker and must deposit **initial margin** into the account. This is a performance bond (i.e. collateral) held against the possibility that the trader may not meet the contractual obligations. The clearing house stipulates the minimum initial margin that must be deposited. The amount varies according to the type of contract and is based on a calculation of the maximum likely movement in the value of the futures contract over a close-out period.

Marking-to-Market

At the end of each day a trader's margin account is adjusted in line with the closing price of the futures contract. This is called **marking-to-market**. It prevents large losses from accumulating on trading positions.

If the price of a futures contract has risen by the end of the day then the profits are added to the margin accounts of the traders who have long positions. The losses are subtracted from the margin accounts of the traders who have short positions. On some exchanges this means that the loss-making trader will automatically have to make a top-up payment called **variation margin** to restore the amount held in the margin account to its original level. Other exchanges use a system of **maintenance margins** such that the value of a contract has to move by a certain amount before a margin call is triggered.

In summary, the effect of the margining system is to provide a very high measure of protection against default. Firstly, traders have to deposit initial margin with the clearing house via their broker before they can take out a position. Secondly, all open positions are marked-to-market on a daily basis. If a trader receives a variation margin call and fails to send the required funds in time, the position will normally be closed out by the broker.

USERS OF FUTURES CONTRACTS

There are three main types of end-users of futures, although the same organization or individual may take different roles in different circumstances.

Hedgers

These are using futures to protect or hedge against adverse movements in commodity prices, equity indices, interest rates, bond prices, etc. Examples include farmers who are seeking protection against a fall in the market price of their crop; fund managers and banks hedging against falls in stock or bond prices; and commercial banks covering exposures to changes in short-term interest rates.

Speculators

These buy and sell futures contracts to profit from changes in commodity prices, interest rates, etc. They are prepared to accept risks that hedgers do not wish to assume, and they provide liquidity to the market – that is, they help to ensure that there is an active market in futures contracts with up-to-date prices, and that at any given time buyers and sellers are both in operation.

Arbitrageurs

These look to exploit price anomalies by (for example) simultaneously trading in futures and the underlying assets. If a futures contract is trading 'rich', i.e. at an expensive level, an arbitrageur will short the overvalued futures and at the same time buy (go long) the underlying asset in the spot market.

Overall, the arbitrageur is hedged against general movements in the value of the underlying asset since profits and losses on the short futures will offset those on the long position in the asset. However, the arbitrageur will profit as and when the futures price reverts to its correct market value.

COMMODITY FUTURES

Some readers may have seen the film *Trading Places*, released by Paramount Pictures in 1983, starring Dan Aykroyd and Eddie Murphy. A key scene depicts frenzied trading in Frozen Concentrated Orange Juice (FCOJ) futures. Trading took place on the New York Cotton Exchange. The successor organization, the New York Board of Trade (NYBOT), was later acquired by IntercontinentalExchange in 2007, and is now named ICE Futures U.S.

FCOJ futures have traded in New York since 1967. The current contract, known as FCOJ-A, is based on the delivery of 15 000 pounds of orange solids. The quality of the FCOJ that can be delivered is also specified, as are the licensed warehouses around the US where delivery can take place. Delivery on all contracts is guaranteed by the clearing house ICE Clear U.S. Starting with the July 2009 contract, the product that can be delivered can originate from the US, Brazil, Mexico or Costa Rica. The current contract specification is shown in Table 4.1.

As is common with futures, few contracts ever reach the point of delivery. Contracts are bought and sold many times, and before the delivery month is reached many traders start to close out their positions. Those who are long contracts sell out and those who are short buy back. Over all the exchanges it is estimated that fewer than 4% of futures contracts ever reach delivery, in some cases fewer than 1%. This is fortunate because there are not enough physical commodities in the world to deliver against all the futures contracts that are traded.

Example: Trading FCOJ Futures

The forthcoming January FCOJ-A contract is trading at 115.00 cents per pound ($1.15). A trader believes that orange juice production will be disrupted, and buys futures contracts. If later on the trader's forecast looks increasingly likely to be fulfilled then the futures price will tend to rise on the exchange. Suppose the price increases to 125.00 cents per pound ($1.25). The trader then sells the futures contracts. The profit is:

$$(\$1.25 - \$1.15) \times 15\,000 = \$1500 \text{ per contract}$$

The trader has sold before expiry. The profit is realized in cash and so no actual orange juice is delivered.

Table 4.1 FCOJ-A futures contract specification

Unit of trading:	15 000 pounds of orange juice solids
Price quotation:	Cents and hundredths of a cent per pound
Settlement:	Physical delivery to licensed warehouses in Florida, New Jersey and Delaware
Trading months:	January, March, May, July, September, November

Source: ICE Futures U.S.® Contract details are subject to change and the reader should contact ICE Futures U.S. for current contract specifications.

The primary factors affecting the price of FCOJ futures contracts are the market forces of supply and demand that change the price of orange juice in the spot market. Demand has tended to decline over time. However one of the key features of this market is the extreme difficulty in forecasting supply, due to the uncertainties posed by weather-related factors such as frost and hurricanes. This can lead to sharp price movements.

FUTURES PRICES AND THE BASIS

The total number of long or short futures contracts still open, not yet closed out, is called **open interest**. It tends to be at its highest with the nearby (upcoming) delivery month. As a contract approaches the delivery date, traders start to close out their positions, and open interest for that delivery month declines. Traders who wish to maintain their exposure will 'roll' their position by opening a new position in the next delivery month.

Chapter 2 explained that the theoretical forward price of an asset can be determined by what it would cost to buy it in the spot market, and then adding on the cost of 'carrying' or holding it to deliver to a buyer on a future date. Carry costs can include funding, storage, insurance, etc. Although futures operate in a slightly different way to forwards, it is conventional to extend this so-called **cash-and-carry** method to certain futures contracts.

Backwardation and Contango

Chapter 2 also explained that the cash-and-carry method works well as a way of assessing fair value with futures on financial assets and on some commodities, but not with others. In the oil market, for example, the spot price is often higher than the futures prices, although the simple cash-and-carry method suggests that the situation should be the reverse. When this happens the market is said to be in **backwardation**. When the futures prices are higher than the spot price, the market is said to be in **contango**.

The basis

It is an important aspect generally of trading futures that the **basis** – the relationship between the spot price of the underlying and the price of a futures contract – is not constant. This means, day-to-day, that a futures contract does not exactly track movements in the price of the underlying asset. Changes in the basis are determined by changes in 'carry' costs, such as interest rates and storage charges, but also by speculative trading activity. In some markets the futures price of an asset can be more volatile than the cash or spot price.

As a futures contract approaches its delivery date, however, its price must converge on the spot price of the underlying because, on the delivery day, the futures contract becomes just another spot market transaction. On the delivery day **the basis** – the difference between the spot price and the futures price – must be zero.

This fact allows hedgers to use contracts such as FCOJ futures to manage the risks associated with volatile commodity prices. A food-processing company concerned about increases in the orange juice price can buy FCOJ futures. If the price does rise, it can sell the contracts back into the exchange shortly before the delivery date, and realize a profit in cash that will offset the increased cost of buying orange juice from its suppliers in the spot market.

US TREASURY BOND FUTURES

A **bond** is a debt security issued by a government, bank or corporation. It is like a loan made to the issuer, except that the bond is tradable, i.e. it can be sold on to another investor. A standard or 'vanilla' bond pays fixed interest amounts called **coupons** on regular dates and also pays a **par** or face or redemption value at maturity. US Treasury bonds are issued by the US Treasury and are considered very safe low-risk investments.

US Treasury Bond Example

An investor buys \$100 000 par value of a US Treasury bond which matures in 30 years. The coupon rate is 5% p.a. paid semi-annually. The investor will receive coupons of \$2500 every six months (half of 5% of the par value) plus \$100 000 par value at maturity. Alternatively, the investor can sell the bond before maturity.

The 30-year US Treasury Bond Futures contract has been traded on the Chicago Board of Trade (CBOT) since 1977 and has proved extremely popular ever since. The current contract specification is set out in Table 4.2. In 1982 the exchange introduced options on Treasury bond futures. Since then it has launched a series of other bond futures contracts, including contracts on shorter-maturity US Treasury securities.

A seller of one futures contract (a 'short') is making a commitment to deliver \$100 000 par value of the US Treasury bond stipulated in the contract at a fixed price. A buyer of a bond futures (a 'long') is committing to take delivery at a fixed price. The delivery months available are March, June, September and December. Delivery can take place on any business day in the delivery month, at the choice of the short.

Tick size and tick value

The T-bond futures price quotation is made in fractions of a dollar rather than in decimal format. In most cases prices are quoted in dollars and thirty-seconds of a dollar per \$100 par value. For example, a quotation of 105–16 means that the contract is trading at \$105 and 16/32 per \$100 par value. This is \$105.50 in decimal format.

The **tick size** mentioned in Table 4.2 is the minimum move allowed in the price quotation. The value of a one tick move in the futures price on a contract (based on \$100 000 par value)

Table 4.2 CBOT 30-year US Treasury bond futures contract specification

Unit of trading:	\$100 000 par value of a notional US Treasury bond with a 6% coupon rate
Contract months:	March, June, September, December
Price quotation:	The futures price is quoted as a percentage of par i.e. per \$100 par value
Tick size:	The tick size (minimum price move) on most contracts is 1/32%
Tick value:	\$31.25
Delivery:	The contract is written on a notional bond. A range of actual bonds can be delivered against the contract provided they have a maturity of at least 15 years from the first day of the delivery month.
Delivery date:	Any business day in the delivery month
Last trading day:	Seven business days before the last business day of the delivery month

Source: CME Group

is calculated as follows.

$$\$100\,000 \times \frac{1}{32}\% = \$31.25$$

Bond futures profit and loss calculations

What all this means in practice is as follows:

- long and short US Treasury bond futures positions are marked-to-market at the end of each trading day based on the closing price of the contract on the exchange;
- each one tick movement in the quoted price results in a profit or loss per contract of $31.25;
- if the price rises (falls) the traders who are long futures make profits (losses);
- if the price rises (falls) those who are short futures make equal and opposite losses (profits);
- all profits and losses from that day's trading are added to or subtracted from a trader's margin account.

For example, suppose a trader buys a T-Bond futures contract one day at 105–16 and at the end of the day the contract closes exactly one tick higher at 105–17. The trader has made a profit of one tick per contract, which is worth $31.25, and this will be added to his or her margin account.

US TREASURY BOND FUTURES: DELIVERY PROCEDURES

US Treasury bond futures are **physically delivered** contracts, which means that a trader who is still short contracts during the delivery month can decide to deliver US Treasury bonds and submit an invoice for those bonds. The 'short' has the choice of which day in the month to do this. The bonds are delivered to a trader who is long futures contracts, and who has to pay the invoiced amount for those bonds. The delivery and settlement process is guaranteed by the clearing house, in order to eliminate the risk of non delivery or non payment.

In practice, relatively few traders actually go through the delivery process. Before the delivery point is reached many longs and shorts close out their positions by respectively selling and buying back contracts. However delivery can and does take place.

Conversion or price factors

One important point to stress is that the contract is written on a *notional* or imaginary US Treasury bond. This is actually very helpful, since if it was based on a real bond the contract could not be traded after that security had matured. It is not, of course, possible to deliver imaginary assets, so the CBOT publishes a list of real US Treasuries that can be delivered against a contract, plus a list of so-called **conversion factors** designed to adjust for the fact that different bonds trade at different market prices. (On NYSE Liffe these are called **price factors**.)

The conversion factors on the US 30-year Treasury bond futures are obtained by pricing all the deliverable bonds at a yield (annualized rate of return) of 6%. In the absence of conversion factors all the 'shorts' would tend to deliver cheap, low coupon Treasuries. The conversion factor adjusts the payment received by the short when delivering securities to the long. The invoiced amounts for a low and for a high coupon bond are adjusted downwards and upwards respectively.

GILT FUTURES

A wide variety of bond futures contracts is now available around the world. For example, NYSE Liffe offers a long gilt (UK government bond) futures contract that is similar to the 30-year US Treasury contract traded on the CBOT. Each contract is a commitment to deliver or take delivery of GBP 100 000 notional gilts with a 6% coupon at a fixed price. The price quotation is made in decimal format per GBP 100 par or nominal value.

The tick size (minimum move) in the futures price is GBP 0.01 per GBP 100 par value. This means that if a trader buys a futures at a price of (say) 110.00 and the price on the exchange rises by one tick to 110.01, then the trader has made a profit on the contract of GBP 10.

$$\text{Tick size} = \text{GBP } 0.01 \text{ per GBP } 100 \text{ par value}$$
$$\text{Tick value} = \text{GBP } 100\,000 \times 0.01\% = \text{GBP } 10$$

The exchange publishes a list of British government bonds that are deliverable against the contract. A trader who is short futures has the choice of which bond and which business day in the delivery month to make delivery. The invoiced amount is adjusted by the price (conversion) factor of the bond that is actually delivered.

THE CHEAPEST-TO-DELIVER (CTD) BOND

When a bond futures contract with a given delivery month first starts to trade, a list of deliverable bonds and their conversion factors is issued by the exchange. The conversion factors are fixed and do not change when the contract starts to trade. For people who are hedging a long position in bonds by shorting bond futures this is important, since they need to know the conversion factors to calculate the number of contracts to sell.

Unfortunately, the system is not perfect and the conversion factors do not fully adjust for the actual market values of the bonds that are deliverable against a bond futures contract. The factors are based on pricing all the deliverable bonds at exactly the same annualized rate of return, but, in reality, bonds with different maturities tend to have different yields or returns in the market.

This means that at any one time there tends to be a so-called **cheapest-to-deliver** (CTD) bond. Literally, this is the bond that will make the most money (or lose the least) if it is purchased on credit and delivered against a short position in the futures. Most shorts will tend to deliver the CTD and longs will expect to receive that bond, so that the futures contract tends to behave rather as if it were based on the current CTD and to track movements in the market value of that bond.

Changes in the CTD

The bond that is the current CTD can *change* over the life of a bond futures contract. It is affected by the level of interest rates in the market. When market rates are below the coupon rate on the notional bond specified in the futures contract, the CTD tends to be a higher coupon bond with a shorter maturity. In a high-interest rate environment it tends to be a lower coupon bond with a longer maturity.

The practical difficulty is clear enough. Hedgers who sell bond futures to protect against losses on a long position in a bond or a portfolio of bonds usually calculate the number of contracts they have to short on the assumption that the futures will track changes in the current CTD. That is a reasonable assumption. However, if *another* bond becomes the CTD then the futures will change partners, and its price behaviour will be quite different from what it was previously. Consequently, the hedge will no longer be as accurate as predicted, and profits and losses on the bonds that are owned, and on the short futures, may not match particularly well.

CHAPTER SUMMARY

A futures contract is a commitment made on an organized exchange to deliver or take delivery of a specified amount of a commodity or financial asset in the future at a fixed price, or to make a cash settlement based on the difference between the fixed price and the value of the underlying at expiry. Some contracts have a range of possible delivery dates. Delivery and settlement are guaranteed by the clearing house associated with the exchange.

The fair value of a financial futures contract can be established through a cash-and-carry calculation – the cost of buying the underlying in the cash market plus the net cost of carrying it to deliver on a future date. However futures contracts do not always trade at fair value, and this may give rise to arbitrage opportunities. The relationship between the spot price of the underlying and the price of a futures contract on the underlying is called the basis. The basis is not constant and is affected by factors such as changes in interest rates as well as by speculative activity on the exchange.

A bond futures is a commitment to deliver or take delivery of a notional bond on a future date or between a range of dates. The exchange publishes a list of the bonds that are deliverable against a given contract, at the choice of the short, with their conversion or price factors. These factors are designed to adjust the invoiced amount according to the value of the bonds that are actually delivered.

At any one time there tends to be a bond that is the cheapest-to-deliver (CTD) against a short bond futures position, and the futures contract tends to track movements in the price of the current CTD bond. This can cause problems when using bond futures to hedge risks, since if a different bond becomes the CTD the hedge may not work well. However changes in the current CTD can provide opportunities for arbitrage traders.

5

Interest Rate and Equity Futures

INTRODUCTION

Chicago Mercantile Exchange (CME) introduced the Eurodollar futures contract in 1981. It is widely used by banks and other financial institutions to hedge against changes in funding and investment rates. It is also used by traders who wish to anticipate and profit from increases or reductions in short-term US dollar interest rates. To give some give idea of its importance, six million contracts were traded in one day on Friday 5 June 2009.

Eurodollars

Eurodollars are simply time deposits in US dollars held in commercial banks outside the USA. The bulk of the market is based in London. The 'Euro' prefix is historical in origin and has nothing to do with the single common European currency. The market grew up in the years after the Second World War when large pools of dollars accumulated in London and other international financial centres outside the US.

The CME Eurodollar futures broke new ground because it is **cash-settled** rather than through the physical delivery of a commodity or financial asset. The technique is explained in the next section.

Cash settlement is now used for a wide range of contracts on exchanges around the world. It is used in equity index futures, so that it is possible to profit from or hedge against changes in the level of major stock market indices without ever actually buying or selling the underlying shares. This helps to reduce transaction costs and allows traders to take a position in equities at a fraction of what it would cost to buy and sell the underlying shares. Cash settlement is also used with newer products such as weather derivatives (see Chapter 1).

In Europe, the futures contract on short-term deposits in euros (the new single currency) traded on NYSE Liffe has also proved extremely popular. The exchange also offers a contract on three-month sterling interest rates.

EURODOLLAR FUTURES

Table 5.1 shows the contract specification for the three-month Eurodollar interest rate futures traded on CME.

A Eurodollar deposit is a term deposit with a bank for a specific period of time such as one week, three months or six months. Most deals are for maturities of one year or less. The interest rate is fixed for that period, and the principal amount deposited is repaid with interest at maturity.

The key reference rate for Eurodollar loans and deposits is **US dollar LIBOR**, which is fixed every London business day by the British Bankers' Association (BBA) based on rates submitted by a panel of contributor banks. The BBA fixes rates for a range of maturities

Table 5.1 CME Eurodollar futures contract specification

Unit of trading:	Eurodollar time deposit with a principal value of \$1 million and a three-month maturity
Contract listing:	March, June, September, December and other months
Quotation:	100.00 minus the implied interest rate for the future time period covered by the contract
Full tick size:	0.01 (representing in interest rate terms one basis point p.a., i.e. 0.01% p.a.)
Full tick value:	\$25
Settlement:	Cash-settled

Source: CME Group

ranging from overnight to one year. (Chapter 3 has given additional information on LIBOR rates.)

The CME Eurodollar futures contract is based on a notional \$1 million three-month Eurodollar deposit starting on a specific date in the future – the third Wednesday of the contract month. In fact the notional amount never actually changes hands. It is used to calculate the profits and losses on trading positions in the futures contract.

The value of a contract changes on a day-by-day basis according to the **expected interest rate** for the future time period it covers. For example, the value of a March contract depends on the expected interest rate on a \$1 million Eurodollar deposit starting on the third Wednesday in March and running for three months from that date. A trader who is long or short the futures will make or lose money as that expectation changes, and as the market value of the contract fluctuates.

Final settlement value

The last trading day of a contract is different. It ceases trading two business days before the third Wednesday of the contract month, because the *actual* three-month LIBOR rate for the period it covers is fixed by the BBA at that point. This establishes the final settlement value of the contract. Any contracts still outstanding on the last trading day are automatically closed out at that value.

TRADING EURODOLLAR FUTURES

Unlike a forward rate agreement (see Chapter 3), the price of a Eurodollar futures is not quoted in interest rate terms. It is quoted as 100.00 minus the rate of interest per annum for the future time period covered by the contract. The quotation convention was adopted to make life simpler for traders because it makes the Eurodollar futures prices behave like the prices of cash market securities such as Treasury bills. They know that if expected interest rates are rising (falling) they should be thinking about selling (buying) interest rate futures.

Table 5.1 refers to the contract **tick size**. A tick is a small move in the price of a financial asset. A full tick movement in the price of a Eurodollar futures contract is set by the exchange at 0.01. For example, if the price rises from 98.00 to 98.01 this is a full tick change. It has a value of \$25, as shown in the following box.

Tick Size and Value

A full tick movement in the price of a Eurodollar futures contract is 0.01. In interest rate terms this represents one basis point i.e. 0.01% p.a. The contract is based on a \$1 million three-month LIBOR deposit. Each full tick move in the price of a contract represents a profit or loss of \$25. This is the tick value.

$$\text{Tick value} = \$1 \text{ million} \times \frac{0.01\%}{4} = \$25$$

The interest rate is divided by four because it is quoted per annum but the contract covers a quarter year.

Calculating trading profits and losses

Suppose that the March Eurodollar futures is being dealt on the exchange at 98.00, implying a rate of 2% p.a. for the three-month period starting in March.

A trader who thinks that the actual LIBOR rate for this period will be fixed *below* this level decides to buy March futures. In this case the view turns out to be correct, and on the last trading day of the contract the LIBOR rate for the period is set by the BBA at 1% p.a. The contract will close on its last day at a value of $100.00 - 1.00 = 99.00$, above the price paid by the trader, who has made a profit as follows.

$$\text{Change in contract value} = 99.00 - 98.00 = 100 \text{ ticks}$$
$$\text{Profit per contract} = 100 \text{ ticks} \times \$25 = \$2500$$

On the other hand, if LIBOR is fixed *above* 2% p.a. then the contract will close *below* the purchase price of 98.00 and the trader will suffer a loss.

Profits and losses in interest rate terms

In interest rate terms, buying a March futures at 98.00 is equivalent to taking the view that the actual LIBOR rate for the three-month period starting in March will be set lower than 2% p.a. If the LIBOR rate for the period is actually fixed at 1% p.a. the profit on the trade per contract can also be established as follows.

$$\text{Notional contract size} = \$1 \text{ million}$$
$$\text{Profit} = \$1 \text{ million} \times \frac{2\% - 1\%}{4} = \$2500$$

Again, the difference between the rates is divided by four here because they are quoted on a per annum basis but the contract only covers a quarter of a year.

Close out before expiry

In practice, many traders close out their positions before the last trading day of a contract. However, the basic principle of trading remains the same.

If a trader buys a contract at a certain price and the expectation develops that the actual interest rate for the period covered by the contract will be lower than the rate implied in

Table 5.2 Hedge with Eurodollar futures bought at 98.00

(1) Reinvestment rate (% p.a.)	(2) Deposit interest ($)	(3) Futures close price	(4) Tick change	(5) Futures profit/loss ($)	(6) Interest + profit/loss ($)	(7) Effective rate (% p.a.)
1.0	2500	99.00	100	2500	5000	2.0
1.5	3750	98.50	50	1250	5000	2.0
2.0	5000	98.00	0	0	5000	2.0
2.5	6250	97.50	−50	−1250	5000	2.0
3.0	7500	97.00	−100	−2500	5000	2.0

The columns in Table 5.2 are as follows:
Column (1) has a range of possible reinvestment rates in March, when the investment will be rolled over.
Column (2) calculates the interest received at that rate, based on $1 million deposited for three months.
Columns (3) and (4) calculate the price at which the futures would close in each case and the change in price from a starting level of 98.00.
Column (5) calculates the overall profit or loss on the futures (the sum of all the daily variation margin payments and receipts over the life of the contract). For example, if LIBOR is fixed at 1% then the futures will cease trading at 99.00. This is 100 ticks above the purchase price so the profit is $2500.
Columns (6) and (7) add the interest in column (2) to the futures profit/loss in column (5), and calculate the effective rate of interest per annum achieved on the basis of $1 million reinvested over three months.

this price, then the price of the futures will increase on the exchange. The trader can sell the contract back into the market and realize a profit in cash.

HEDGING WITH INTEREST RATE FUTURES

Like forward rate agreements (see Chapter 3), Eurodollar futures can be used to lock into a rate for borrowing or reinvesting cash on future dates. This section explores a typical case.

Suppose that it is mid-December and in three months' time an investor will have to reinvest $1 million for a further period of three months. The cash will come from existing investments due to mature at that point. If the investor does *not* hedge this exposure, and if interest rates decline, then the investor will suffer from falling reinvestment returns.

To manage this risk the investor buys one March Eurodollar futures contract at a price of 98.00. Table 5.2 shows the results of the hedge. For simplicity the difference between market lending and borrowing rates and the full complications of the daily margin system on the futures contracts are ignored in this example.

Eurodollar futures hedge in a graph

As a result of the futures hedge the investor is locked into a reinvestment rate of 2% p.a. for the three-month period starting in March. This is illustrated in Figure 5.1. The graph also shows the variable return on investment achieved if the investor does *not* use the futures hedge.

INTEREST RATE FUTURES PRICES

The fact that Eurodollar futures can be used to lock into rates for reinvesting dollars on future dates means that the market price of a contract has to be closely related to spot or cash market dollar interest rates. (The spot market is the market for borrowing and lending funds starting now rather than in the future.) If this were not the case then arbitrage opportunities would arise.

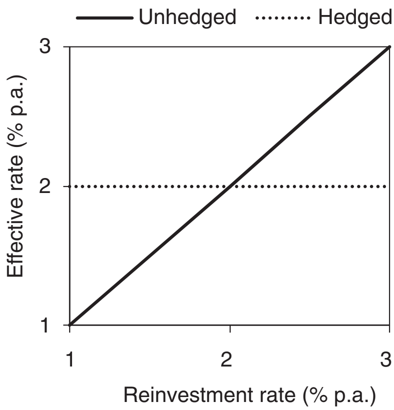

Figure 5.1 Using Eurodollar futures to lock into a reinvestment rate

Arbitrage example

Suppose, as previously, that it is mid-December but that this time the March futures could be bought on the exchange at a price of (say) 95.00 rather than 98.00. This means that if a trader buys a contract he or she can lock into a rate of 5% p.a. for reinvesting dollars in three months' time for a further three-month time period. The trader looks at dollar interest rates on the spot market and discovers that they are as follows:

- **Six Months**. The rate for borrowing dollars for six months starting now in mid-December is 1.5% p.a.
- **Three Months**. The rate for depositing dollars for three months starting now is 1% p.a.

An arbitrage is then available. The trader arranges to borrow dollars for six months at 1.5% p.a. The trader puts the funds on deposit for three months at 1% p.a. The proceeds from this deposit will be paid out next March, and will have to be reinvested for a further three months so that cash is available in six months' time to repay the principal plus interest on the loan. However the trader locks into a rate of 5% p.a. for reinvesting that money by buying (also in mid-December) the March Eurodollar futures contract at 95.00.

This combination of deals generates an arbitrage profit.

- **First Three Months**. The deposit rate is 1% p.a. but the borrowing rate is 1.5% p.a., a shortfall of 0.5% p.a.
- **Second Three Months**. The guaranteed reinvestment rate is 5% p.a. and the borrowing rate is 1.5% p.a., which provides a benefit of 3.5% p.a.

Here the interest rate benefit or 'pickup' over the second three months more than offsets the shortfall for the first three-month period, and a 'free lunch' is achieved.

No arbitrage relationships

In order for this arbitrage to disappear, the futures price would have to trade at around 98.00, so that the rate for reinvesting money for three months in three months' time is approximately 2% p.a. In that case the costs and gains all cancel out:

- **First Three Months**. The shortfall as before is 0.5% p.a.

- **Second Three Months**. The benefit this time is only 0.5% p.a. (i.e., 2% minus the 1.5% borrowing rate).

In fact the reinvestment rate that can be achieved by buying the futures for no arbitrage to be available should be slightly less than 2% p.a. This is because it is possible to reinvest not only the original amount of dollars borrowed but also the interest received for the first three months. In practice, also, factors such as transaction costs come into the equation, particularly with longer-dated interest rate futures.

EQUITY INDEX FUTURES

An equity index futures contract is an agreement:

- made between two parties;
- on an organized futures exchange;
- to exchange cash settlement payments;
- based on the movements in the level of an equity index.

One of the most liquid contracts is the S&P 500 index futures traded on CME. It was introduced in 1982. Deals are currently made either electronically or on the floor of the exchange.

The underlying cash index is calculated by Standard & Poor's. It represents the value of a portfolio of 500 leading US shares. The weight of a share is in proportion to the **market capitalization** of the company (share price times the number of shares outstanding). The total market capitalization of the S&P 500 index as at 15 January 2010 was about $10 116 billion.

With the CME S&P 500 index futures there is no physical delivery of the underlying portfolio of shares that comprise the index. Instead there is a **cash settlement** procedure. It would simply be too cumbersome for a trader who is short contracts to deliver all the 500 shares in the correct proportions. Instead, each full S&P index point is assigned an arbitrary $250 monetary value and profits and losses on the futures are settled in cash. This contrasts with commodity and bond futures (see Chapter 4) where there is physical delivery.

CME S&P 500 futures price quotation and basis

As with most derivatives, the price of an S&P 500 futures contract is quoted in the same units as the underlying – in this case the underlying is the S&P 500 index, so the futures price is quoted in index points. The underlying index is called the **cash market** since its level reflects the cash values of the 500 shares that comprise the index.

Equity Index Futures Basis

The futures price on the exchange is driven up and down by changes in the underlying cash index level, and ultimately by changes in the values of the constituent shares. However the relationship between the cash market and the futures is not completely stable. In other words, if the cash market moves by a certain number of index points it does not follow that the futures price will change by exactly the same extent. As we have seen before, the relationship between the cash and the futures price is known as **the basis**.

One technical reason why the basis is not constant emanates from changes to the cost of carry (the interest rate less dividends on the shares in the index).

Another factor is supply and demand. If it looks as if there may be a slide in the market then traders rush to sell the index futures, often pushing the price down more quickly than that of the underlying cash index. If the market then rallies, traders start to buy back index futures to close out their short positions, propelling the futures price sharply upwards.

Other major equity index futures contracts

CME has also introduced an E-mini S&P 500 futures contract, mainly aimed at the retail market, and which is traded electronically. In this contract each full index point is worth $50. CME offers a range of other contracts on well-known indices such as the Japanese Nikkei 225 (with points denominated in US dollars or in yen).

Other major contracts around the world include the FT-SE 100 futures, based on the index of the top 100 blue-chip UK shares, which is traded on NYSE Liffe. Futures on the DAX, the index of the shares of the largest 30 German companies, are traded on Eurex.

APPLICATIONS OF S&P 500 INDEX FUTURES

To illustrate the cash settlement process, suppose that it is now August and the September S&P 500 futures contract is trading on CME at 1000 index points.

A day-trader buys 10 S&P 500 September index futures contracts at a price level of 1000 points. The trader believes that the underlying market – the cash index – is set to rally strongly before the end of the day. If this happens then the futures price will rise in sympathy. The trader contacts a broker to have the order transacted, and posts the required **initial margin**. As discussed in Chapter 4, initial margin is a performance deposit and will be returned later, assuming that the trader fulfils the contractual obligations. It is *not* the cost of the contracts.

Suppose this time that the trader is correct in the forecast, and the September S&P 500 futures rises later that same day to a price of 1050 points, propelled upwards by a strong rally in the underlying cash market.

The trader can then close out the long futures position by selling 10 September futures in the exchange. The profit from buying and then selling the contracts (ignoring brokerage and funding costs) is calculated as follows. The profit is realized in cash rather than through the delivery of shares.

$$\text{Profit} = 10 \text{ contracts} \times \$250 \times (1050 - 1000 \text{ points}) = \$125\,000$$

Hedging with equity index futures

Using equity index futures is not always about speculation. A portfolio manager who is concerned about losses arising from falls in the stock market can short (sell) contracts on the S&P 500 or on some other index which the portfolio tends to track. If the market falls then losses on the portfolio will be offset by profits on the short futures position.

Drawback to Hedging with Futures

There is a drawback to this type of hedge. If the market rises, then any *gains* on the portfolio of shares will be offset by *losses* on the short futures position. When considering a hedge of this kind, the skill is in timing – knowing when to sell futures to manage the risk on a portfolio of shares, and knowing when to leave well alone. Alternatively, the fund manager can buy **put options** on the index. If the market falls these will generate a profit in cash; but if it rises the fund manager will not have to pay out anything. The downside here is that, unlike futures, options have an up-front cost called the **premium** (see Chapter 9).

FT-SE 100 INDEX FUTURES CONTRACTS

As discussed in Chapter 4, the role of a futures exchange and the associated clearing house is to facilitate trading, to settle deals, to broadcast prices and generally to ensure an orderly market. In addition, the clearing house acts as a central counterparty and stands between buyers and sellers of contracts. It manages the credit risk on its clearing members, which in turn act as intermediaries for client transactions (see Chapter 20).

For a non member of an exchange, opening an index futures position (whether buying or selling) involves depositing **initial margin** (collateral) with a broker. The broker handles payments made to and received from the clearing house. At the end of a day, open positions are **marked-to-market** so that profits and losses are added to or deducted from the trader's margin account.

To illustrate the margining process, this section examines a short trading campaign based on FT-SE 100 index futures. These are traded on NYSE Liffe in London, and deals are matched electronically through the exchange's computer system. All trades are cleared by LCH.Clearnet Ltd. The contract specification is shown in Table 5.3.

Trading campaign: Day 1

The September FT-SE 100 futures is trading at 5000 index points. A trader decides to buy 10 contracts, and contacts a broker. The broker asks for GBP 3000 initial margin per contract, or GBP 30 000 on the whole trade.

The trader lodges the money with the broker, which in turn pays margin over to the clearing house. The broker transacts the order electronically and buys for the trader 10 September FT-SE 100 futures at a price level of 5000 index points. The other side of the transaction is taken by a seller of the September futures. As soon as the deal is transacted, however, the clearing house interposes itself, acting as a central counterparty.

Table 5.3 FT-SE 100 index futures contract

Underlying:	FT-SE 100 index of top UK shares
Quotation:	FT-SE 100 index points
Point value:	GBP 10 per full index point
Tick size (value):	0.5 index points (GBP 5)
Expiry months:	March, June, September, December

Source: LIFFE Administration and Management

The trader could close out the long futures position later the same day, simply by selling 10 September futures. Instead, the trader decides to run the position overnight. Suppose that the futures closes at the end of the day at 4970 index points, 30 points below the price at which the position was originally opened, driven down by a fall in the cash index. The trader will receive a **variation margin call** to make good the difference between the purchase price and the closing or settlement price of the September futures.

$$\text{Variation margin payable} = -30 \text{ points} \times 10 \text{ contracts} \times \text{GBP } 10 = -\text{GBP } 3000$$

The effect of the margin system is that trading profits and losses are realized on a daily basis and so do not accumulate. If the trader does not make the margin call the broker will sell the 10 contracts, closing out the original position, and return the initial margin lodged minus the GBP 3000 trading loss and any other costs.

In this example the futures price has fallen. Variation margin is collected from traders with long positions and credited to the accounts of the 'shorts' – the market participants who are short FT-SE 100 index futures. Note that each full index point is worth GBP 10.

Trading campaign: Day 2

On the next trading day suppose that the September futures closes at 5020, which is used as the settlement price to calculate variation margin payments for that day. The trader is still long 10 contracts and the settlement price is 50 points above yesterday's value of 4970. This time the trader *receives* variation margin.

$$\text{Variation margin received} = 50 \text{ points} \times 10 \text{ contracts} \times \text{GBP } 10 = \text{GBP } 5000$$

The futures price has risen, driven upwards by the cash FT-SE 100 index, ultimately by the prices of the constituent shares. This time it is the shorts who have to make variation margin payments.

Trading campaign: Day 3

Finally, on Day 3 the trader decides to close the long position by putting in an order to sell 10 September futures either **at best** (at the best available market price) or on a **limit order** basis (at a price that is not less than a stipulated level). Suppose that the broker transacts the sell order at 5030. The trader is entitled to a final variation margin payment because the contracts were sold 10 points above the last settlement price.

$$\text{Variation margin received} = 10 \text{ points} \times 10 \text{ contracts} \times \text{GBP } 10 = \text{GBP } 1000$$

ESTABLISHING NET PROFITS AND LOSSES

The position is now closed, so the trader can take back the initial margin, which was only a 'goodwill' deposit. The net profit on the whole trading campaign is the sum of the variation margin payments and receipts.

$$\text{Net profit} = -\text{GBP } 3000 + \text{GBP } 5000 + \text{GBP } 1000 = \text{GBP } 3000$$

Alternatively, it is the price at which the futures were sold less the price at which they were originally bought, times the index point value, times the number of contracts traded.

$$\text{Net profit} = (5030 - 5000) \times \text{GBP } 10 \times 10 \text{ contracts} = \text{GBP } 3000$$

Note that this profit was achieved on an outlay of only GBP 30 000 initial margin. At an index level of 5000, each futures contract (at GBP 10 per point) provides a market exposure equivalent to buying shares in the underlying FT-SE 100 index to the value of GBP 50 000. This means that the trader in the example would have had to invest a total of GBP 500 000 in *actual* shares to acquire the same exposure achieved by buying 10 futures. The initial investment would have been much higher, and the return on investment much lower.

Exchange delivery settlement price (EDSP)

The mark-to-market procedure is repeated every day until the FT-SE 100 index futures position is closed out. The contracts expire on the third Friday of the contract month, and trading ceases as soon as possible after 10:15 a.m. London time. At the expiry all remaining open positions are settled in cash against the **EDSP.**

- The EDSP is currently based on the value of the underlying cash FT-SE 100 index established through an auction run at the London Stock Exchange on the last trading day.
- In the absence of a physical delivery mechanism, this ensures that the futures contract value will converge on the cash index level at expiry.

If a position is retained until the last day there is a final variation margin payment based on the EDSP and then the contracts simply expire – there is no physical delivery of shares.

SINGLE STOCK FUTURES (SSFs)

In January 2001 LIFFE in London first introduced futures contracts on individual shares, and other exchanges started to introduce similar products. For example, the German-Swiss exchange Eurex offers SSFs on a range of European, US and other shares in a range of currencies. Like equity index futures most of these are **cash-settled**, rather than through the physical delivery of shares. Profits and losses are based on the difference between the price at which a contract was bought or sold and the price at which the position is closed out.

In the US the key market now is OneChicago which is a joint venture of IB Exchange Corporation, CME Group and the Chicago Board Options Exchange (CBOE). OneChicago is an electronic market. It lists single stock futures contracts on major shares such as Apple, IBM and JP Morgan Chase. The normal contract size is 100 shares. SSF contracts on OneChicago are **physically settled**. That is, they are commitments to deliver or to take delivery of an agreed number of shares on a designated date in the future, shortly after the contracts expire.

Advantages of SSFs

With SSFs only a percentage (typically 20%) of the actual value of the shares being traded has to be put up as initial margin when a trader buys or sells contracts. Also, settlement is guaranteed by the clearing house.

SSFs also make it relatively easy for a trader to take **short positions** in individual shares, i.e. to set up a deal that will make money if the share price falls. The trader simply sells futures and can buy them back at a cheaper price if the share price does decline. If the contracts are physically settled the trader is making a promise to take delivery of shares in the future at a fixed price. Then if the share price falls, the trader will be able to buy the shares cheaply in the cash market and sell them at a higher price through the futures contracts.

In some markets such as (at the time of writing) the UK there are tax advantages to SSFs and equity index futures. Users do not have to pay the stamp duty that is levied by the government on transactions in the underlying shares.

The future of single stock futures

Given their advantages, single stock futures have not yet attracted very high levels of interest from investors. Part of this may simply be due to unfamiliarity. In addition, some investors seem to dislike the margining procedure used with futures, perhaps because of the inconvenience and the need to monitor the payments.

The reason may also be psychological. A trader or investor who owns shares that perform badly can always imagine that the price will recover, and wait for better times. The loss is 'only on paper'. However, if a futures position performs badly the trader will receive variation margin calls to put up additional collateral. Although this can be an inconvenience, it actually imposes good trading discipline. It concentrates the mind and encourages traders to think about cutting loss-making positions.

CHAPTER SUMMARY

A short-term interest rate futures contract is based on the rate of interest on a notional deposit starting at a specific point in the future. The contract price is quoted as 100 minus the expected interest rate. A seller profits if the actual rate is set above the rate built into the contract price at the time the contract was sold. A buyer profits if the rate is set below the rate built into the contract price when it was purchased.

In major currencies the prices of short-term interest rate futures are used to establish the fixed rates on forward rate agreements (FRAs) and shorter-term interest rate swaps. Because interest rate futures can be used to fix the rate of interest for borrowing and depositing money on future dates, their prices have to be closely related to cash market interest rates, otherwise profitable arbitrage opportunities can arise.

An equity index futures contract is an agreement made through an organized exchange to make and receive cash settlement sums based on the value of an equity index such as the S&P 500 in the US or the FT-SE 100 in the UK. No physical shares are exchanged. Index futures can be used to speculate on anticipated rises or falls in the market. The initial margin required is normally a fraction of what it would cost to buy the actual underlying shares. In some markets there are also tax advantages. Fund managers can hedge against losses on share portfolios by shorting equity index futures.

In recent years some exchanges have introduced futures on single shares, known as single-stock futures. Some are settled in cash whilst others are physically settled, i.e. through the actual delivery of shares. The initial margin (performance deposit) required is a fraction of the value of underlying shares specified in the contract.

6

Interest Rate Swaps

INTRODUCTION

In general terms a **swap** is a contract between two parties:

- agreeing to exchange cash flows;
- on regular dates;
- where the two payment legs are calculated on a different basis.

A swap is a bilateral over-the-counter (OTC) agreement directly negotiated between two parties, at least one of which is normally a bank or other financial institution. Once made, the contract cannot be freely traded. On the other hand, it can be tailored to meet the needs of a particular counterparty. As with other OTC derivatives there is a potential credit risk – the risk that the other party to the deal might default on its obligations.

Clearing Arrangements for OTC Derivatives

Following the 2007/8 'credit crunch' regulators in the US and elsewhere have pressed derivatives dealers to increase the use of central clearing arrangements for OTC derivative trades such as swaps. This involves registering an OTC transaction with a clearing house which then acts as central counterparty, taking collateral and guaranteeing the deal against the risk of default. This topic is discussed further in Chapter 20.

In an **equity swap** (see Chapter 7) one payment leg is based on the price of a single stock or on the level of a stockmarket index such as the S&P 500. In a **commodity swap** one leg is based on the price of a physical commodity such as oil. In an **interest rate swap** (IRS) both payment legs are based on interest rates.

Swaps of all kinds are used by corporations, investors and banks to manage their exposures to interest rates, currency exchange rates, share values, commodity prices and loan default rates. They can also be used to take speculative trading positions.

INTEREST RATE SWAP STRUCTURE

The most common type of swap is a **single-currency IRS** in which the payment made by one party is based on a fixed interest rate, and the return payment is based on a variable or floating rate. The floating rate is reset periodically according to a benchmark, normally the London Interbank Offered Rate (LIBOR). LIBOR is discussed in more detail in Chapter 3.

The notional principal is not exchanged; it is used to calculate the sums due on the two payment legs. If the payments are made on the same date they can be netted out, and one party pays the difference to the other. The modern IRS market is huge and has grown at a rapid rate in recent years, as illustrated in Figure 6.1.

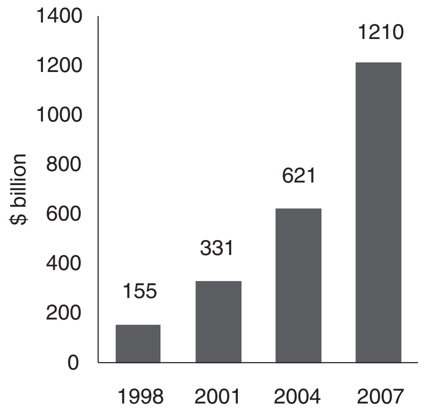

Figure 6.1 Global daily average turnover in single-currency interest rate swaps in April each year
Source: Based on data published by Bank for International Settlements available from www.bis.org

A **cross-currency** IRS is a deal in which the payments are made in different currencies. The payments can either be fixed or linked to a floating rate of interest. There is an example later in this chapter.

Note that this is a quite different type of deal to the FX swap described in Chapter 2. A cross-currency IRS is an agreement to exchange regular cash flows in two different currencies on regular dates. An FX or forward swap is an agreement to exchange two currencies on one date (usually spot) and then to re-exchange them on a later date.

BASIC SINGLE-CURRENCY INTEREST RATE SWAP

The most common IRS is a fixed/floating deal in which the notional principal is not exchanged, but is used to calculate the interest rate payments. This section illustrates the basic structure, using a very simple example which ignores the practical complexities of different day-count conventions and payment frequencies. The example is one in which two parties A and B enter into a three-year IRS starting spot, with the following details:

- **Fixed Leg**. A agrees to pay B a fixed rate of 5% p.a. on a notional $100 million i.e. $5 million p.a.
- **Floating Leg**. In return B agrees to pay A the 12-month dollar LIBOR rate on a notional $100 million.

The notional principal will not be exchanged. The interest payments will be made annually in arrears and will be netted out. There will be three payments in all. The first will be in one year; the second in two years; and the final payment in three years' time. The payment legs for this swap transaction are illustrated in Figure 6.2.

Swap payment in one year

The first payment will occur one year after the contract starts. In fact the LIBOR rate used to calculate this payment will be set at the outset, when the swap is first agreed. Suppose it is set at 4.5%. Then in one year:

- A will owe $5 million on the fixed rate leg of the swap;

Figure 6.2 Interest rate swap payment diagram

- B will owe A $4.5 million on the floating rate leg (4.5% of $100 million);
- the amounts will be netted out and A will pay a net $500 000 over to B.

At this point the LIBOR rate will be *reset* to establish the second swap payment, which is due two years after the start date of the swap. It will be based on the US dollar LIBOR rate announced by the British Bankers' Association on the relevant day in a year's time. Suppose LIBOR happens to be reset at 5.25% p.a. on that day.

Swap payment in two years

This payment will occur two years after the start of the swap. The assumption is that the LIBOR rate for this period is set at 5.25% p.a. In that case:

- A will owe $5 million on the fixed rate leg of the swap;
- B will owe A $5.25 million on the floating rate leg (5.25% of $100 million);
- the amounts will be netted out and B will pay a net $250 000 over to A.

At this point the LIBOR rate will be reset again to establish the third (and final) net payment due on the swap.

THE SWAP AS A PACKAGE OF SPOT AND FORWARD DEALS

Another way to look at the swap just described is as a package of spot and forward interest rate transactions. (Forward interest rates are discussed in Chapter 3 above.) There are three components to the swap deal.

1. **First Payment.** This is due in one year. It is based on the difference between a fixed rate of 5% p.a. and the one-year LIBOR rate which is set at the start of the swap.
2. **Second Payment.** This is due in two years. It is based on the difference between a fixed rate of 5% p.a. and the future LIBOR rate for a one-year period which starts in one year.
3. **Third Payment.** This is due in three years. It is based on the difference between a fixed rate of 5% p.a. and the future LIBOR rate for a one-year period which starts in two years.

The fact that a swap can be built from these basic components allows it to be priced. In simple terms, the fixed rate on a standard single-currency IRS is an average based on the LIBOR rate that establishes the first floating payment and the expected future LIBOR rates over the life of the deal that will establish the subsequent floating payments. (Appendix A has an example.)

Figure 6.3 shows the relevant dates on the swap. This is a somewhat simplified example, however. In practice, swap payments are usually made on a six-monthly or a quarterly basis.

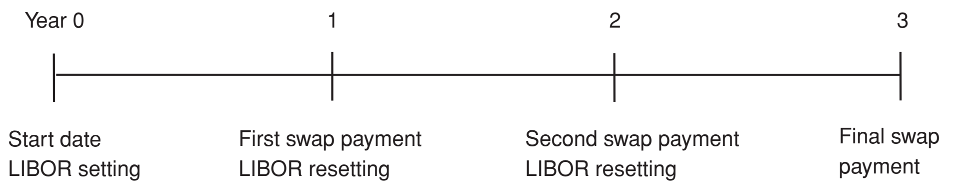

Figure 6.3 Swap payment dates

RATIONALE FOR THE SWAP DEAL

Why would A or B enter into the deal described in the previous sections? Banks and corporates often use swaps to manage interest rate exposures. For example, suppose that A is a corporation which has a three-year loan outstanding on which it pays a variable rate of interest based on one-year dollar LIBOR plus 1%.

Figure 6.4 shows that by overlaying the loan with the swap the company can effectively change from a floating to a fixed rate obligation. Its net cost of borrowing is fixed at 6%. This is the 5% swap rate plus the 1% spread over LIBOR on the loan.

SWAP TERMINOLOGY AND SWAP SPREADS

Some market participants refer to the **fixed rate payer** and the **fixed rate receiver**. In the above example A is the payer of the fixed leg and B is the receiver. Others would call A the **buyer** of the swap and B the **seller**.

Swaps are normally agreed using the standard legal documentation developed by the International Swaps and Derivatives Association (ISDA). The two parties negotiate a master legal agreement using ISDA terms and then any transactions they make are covered by this contract. This means that deals (at least standardized ones) can be transacted quickly by specifying the

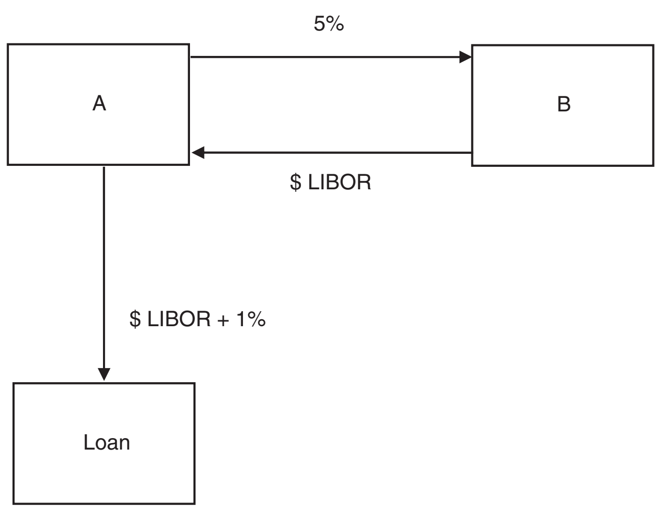

Figure 6.4 Using a swap to fix borrowing costs

terms (fixed rate, maturity, payment frequency etc.) and stipulating that they are covered by the master agreement.

> **Swap Spreads**
>
> Dealers sometimes quote the fixed rates on interest rate swaps in terms of a spread or additional return over the yield or return on the appropriate government bond with the nearest maturity. This is known as the **swap spread**. For example, if the fixed rate on 10-year swaps in euros is 4% p.a. and the yield on 10-year German government bonds is only 3.5% p.a. then the euro swap spread is 0.5% or 50 basis points.

Swap spreads have been taken as an indicator of the additional credit risk the market perceives on swap deals compared to the relatively safe returns available on government securities. Since most swaps are conducted between banks, swap spreads are traditionally sensitive to concerns about the banking system. At times of stress in financial markets they have tended to rise. During the interbank credit crisis in September 2008, when rumours about possible bank losses and failures were rife, swap spreads ballooned out to very high levels.

Overnight index swaps

An **overnight index swap** (OIS) is a fixed/floating IRS in which the floating leg is linked to an index based on overnight interbank interest rates. At maturity one party pays the other the difference between the fixed rate and an average of the overnight rates over the life of the swap, applied to the notional principal.

The **LIBOR OIS Spread** measures the difference between three-month LIBOR and the OIS rate. It is used in the market as an indication of how much cash is available for interbank lending. On 10 October 2008, during the height of the 'credit crisis', the dollar LIBOR OIS spread rose to a record 365 basis points (3.65% p.a.). Historically the typical spread is closer to 10–12 basis points. This indicated a strong reluctance of banks to lend to each other on a three-month horizon because of concerns over default risk. It is a 'fear gauge' reflecting worries over the health of the banking system.

TYPICAL SWAP APPLICATIONS

Swaps can be used to take directional views on interest rates. For example, a speculator who believes that interest rates will rise beyond market forecasts could pay fixed and receive floating on an IRS. If rates do rise as predicted the floating receipts will exceed the fixed payments over the life of the deal.

However, many uses of swaps are concerned with hedging exposures to changes in interest rates. Since an IRS is a contract directly negotiated between two parties the terms can be flexible. A dealer can adjust the payment dates and the notional principal amount to match the needs of a hedger. The following are four typical swap applications.

Fixing a borrowing rate

A company has borrowed on a floating rate basis but is concerned that interest rates will rise.

Solution: the company enters into an IRS with a bank paying fixed and receiving LIBOR. If rates do rise and LIBOR is higher than the fixed rate on the swap the corporate will receive net payments from the bank. This will offset its rising borrowing costs. Alternatively, the company can go back to the bank and terminate the swap. If rates have risen sharply it will receive a substantial close-out payment.

Asset swap

An investor would like a return linked to money market rates. However money dealers will only pay LIBOR minus 1/16%.

Solution: the investor enters into an asset swap deal with a bank. This consists, in effect, of buying a fixed rate bond and at the same time entering into an IRS paying a fixed rate to the bank and receiving a floating rate linked to LIBOR. Depending on the yield or return on the bond (which will depend on its credit risk) the investor can achieve a net return above LIBOR. In return for earning this extra return (which is known as the asset swap spread) the investor takes the risk that the bond will be downgraded or will default.

Asset–liability management (ALM)

A bank is offering fixed rate mortgages to borrowers but funds itself primarily through short-term deposits. If interest rates rise it will pay more in funding than it receives on the mortgage loans. This is a classic ALM problem: the bank's assets (its loan book) are misaligned with its liabilities (its funding).

Solution: the bank contracts an IRS paying away (some of) the fixed receipts from the mortgages and receiving in return a floating rate of interest which it can use to service its borrowings.

Switching to a fixed return

A money market depositor is concerned that interest rates look set to remain at low levels for a number of years ahead and may decline even further in a low inflation environment.

Solution: the investor enters into an IRS to receive fixed and pay floating. The investor has locked into a fixed rate of interest and will not lose out as a result of declining money market rates.

INTEREST RATE SWAP VARIANTS

There are many variants on the basic 'plain vanilla' interest rate swap. The following are some of the most common:

- **Accreting**. The notional principal increases during the life of the swap.
- **Amortizing**. The notional principal reduces during the life of the swap. This feature is useful for a corporate hedging an amortizing loan or bond in which the principal is paid off in instalments and decreases over time.
- **Basis Swap**. A floating-for-floating swap in which the two legs use a different reference rate. For example, one leg pays LIBOR and the other a cash flow linked to short-term corporate borrowing rates.

- **Callable**. The fixed payer can terminate the contract early.
- **Extendable**. One party has the option to extend the life of the swap.
- **Forward-Start or Deferred**. The fixed rate is set when the swap is transacted but the swap starts on a date later than spot.
- **LIBOR-in-Arrears.** The LIBOR rate for the floating leg is fixed at the *end* of a payment period rather than at the beginning.
- **Margin Swap.** The floating rate is LIBOR plus a spread, rather than LIBOR flat. The fixed rate is adjusted accordingly.
- **Off-market Swap.** The fixed rate is different to the current market rate. One party makes a compensating payment to the other.
- **Putable.** The fixed receiver can terminate the contract early.
- **Rate-Capped**. The floating rate payment is capped at a maximum level.
- **Rollercoaster.** The notional principal increases then reduces over time.
- **Spread-Lock.** A forward-start swap in which the swap spread is set at the outset. When the swap starts the spread is added to the yield or return on a reference government bond to establish the fixed rate.
- **Swaption.** An option to enter into an interest rate swap either as the payer or receiver of the fixed rate.
- **Zero Coupon.** There are no interim payments on the fixed leg, only a lump sum payment at maturity.

CROSS-CURRENCY INTEREST RATE SWAPS

In a cross-currency IRS, cash flows in one currency are exchanged on regular dates for cash flows in another currency. The principal is normally exchanged at the spot FX rate at the outset and re-exchanged at the same rate on the final payment date. The regular interest payments can be calculated on a fixed or a floating basis.

In the following case Americo Inc. is a highly-rated US company while Britco plc is a less highly-rated UK firm. Both wish to borrow for five years on a fixed rate basis. Americo wishes to borrow GBP 100 million and pay interest in sterling to finance its UK operations. Britco wishes to borrow $150 million and pay interest in dollars to fund its US activities. The spot rate GBP/USD is 1.5000. Table 6.1 has borrowing rates for each company.

Americo can borrow more cheaply than Britco in either currency, reflecting its higher credit rating. However its **comparative advantage** is greater in dollars than in sterling due to its higher 'name recognition' in the US market. Its advantage in that currency is 1.5% p.a. compared to only 0.75% p.a. in sterling. To exploit this situation, Americo borrows $150 million at 5% p.a. for five years. Its annual interest bill is therefore $7.5 million. Britco borrows GBP 100 million at 6.75% p.a. for five years. Its annual interest bill is therefore GBP 6.75 million. The two firms then approach a swap dealer who agrees the following transactions.

Table 6.1 Five-year fixed rate borrowing costs

Borrower	USD (% p.a.)	GBP (% p.a.)
Americo Inc.	5.00	6.00
Britco plc	6.50	6.75

1. Swap with Americo

- The dealer takes the $150 million which Americo raised on its loan and gives the firm the GBP 100 million it needs for its business operations.
- These amounts will be re-exchanged at the same FX rate in five years on the final swap payment date.
- The dealer also agrees to pay Americo 5% p.a. on $150 million each year for the next five years i.e. $7.5 million. In return Americo will pay the dealer 5.75% p.a. on GBP 100 million i.e. GBP 5.75 million.

2. Swap with Britco

- The dealer takes the GBP 100 million Britco raised on its loan and gives the firm in return $150 million.
- These amounts will be re-exchanged at the same FX rate in five years on the final swap payment date.
- The dealer also agrees to pay Britco 6.75% p.a. on GBP 100 million for five years i.e. GBP 6.75 million. In return Britco will pay 6.35% p.a. on $150 million for five years i.e. $9.525 million.

NET BORROWING COSTS USING A CROSS-CURRENCY SWAP

Figure 6.5 shows the annual interest payments on the swaps and loans in the cross-currency swap case study.

- **Americo**. The net cost to Americo is GBP 5.75 million or 5.75% p.a. on GBP 100 million, which is a saving of 0.25% p.a. or 25 basis points compared to its funding cost if it borrowed sterling directly (see Table 6.1).
- **Britco**. The net cost to Britco is $9.525 million or 6.35% p.a. on $150 million, which is a saving of 0.15% p.a. or 15 basis costs compared to its funding cost if it borrowed dollars directly (see Table 6.1).

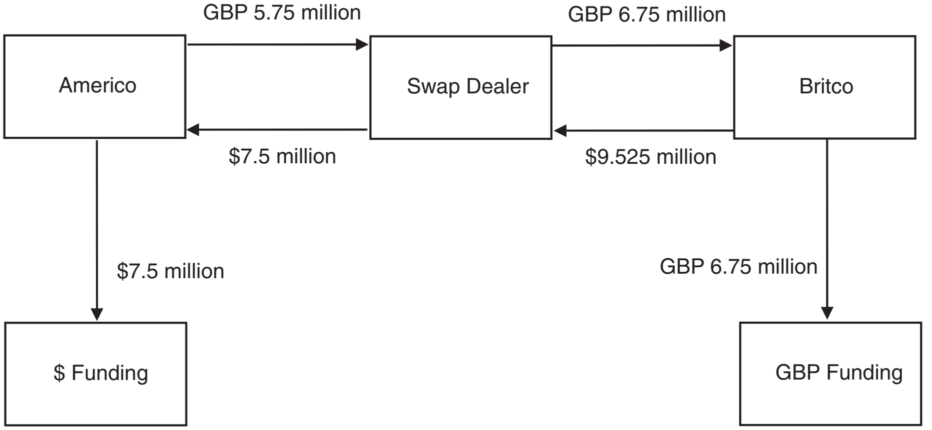

Figure 6.5 Annual interest payments on swaps and loans

The swap dealer's position

For the dealer the principal payments to Americo and Britco at the start and at the end of the swaps simply cancel out. The dealer is left with net cash flows from the annual swap payments as follows:

$$\$9.525 \text{ million} - \$7.5 \text{ million} = \$2.025 \text{ million}$$
$$\text{GBP } 5.75 \text{ million} - \text{GBP } 6.75 \text{ million} = -\text{GBP } 1 \text{ million}$$

There is a residual currency risk on this position since on a net basis the dealer is paying sterling and receiving dollars each year. However this can be hedged using forward FX contracts, as explained in Chapter 2. The deal could also be structured such that Americo or Britco take some or all of the foreign exchange risk.

Why does everyone win?

The answer lies with comparative advantage. Table 6.1 shows that Americo has a substantial advantage over Britco in borrowing in its home currency (the US dollar) where its name is well known. Britco is a lower-rated company, but it is much better recognized in the UK than in the US, and the gap between the borrowing rates is lower in sterling than in US dollars.

So it makes sense for Americo to borrow dollars, for Britco to borrow pounds, and then (via the dealer) for both parties to swap into the currencies they really need.

INFLATION SWAPS

In the 2000s a market started to develop in inflation-linked derivatives. The main application of such products is to transfer inflation risks from one party (the inflation receiver) to the counterparty (the inflation payer).

- **Inflation Receivers**. These are exposed to inflation risk and wish to hedge the risk. They include pension funds and insurance companies making inflation-linked payments to pensioners and policyholders.
- **Inflation Payers**. These receive inflation-linked cash flows. They include utility and real estate companies and sovereign states. They can use inflation derivatives to hedge against variations in the rate of inflation.

Although a range of products has been developed, a key instrument is the **zero coupon inflation swap**. The basic structure is illustrated in Figure 6.6. The deal is a bilateral legal agreement between the two parties.

In the structure shown in Figure 6.6 the inflation receiver pays a fixed interest rate over a specified period (such as five years). The interest is paid at the maturity of the swap rather than in instalments and is compounded over the period. The inflation payer makes a payment based on the actual rate of inflation over the period, as measured by a specified inflation index. This could be a measure such as the Consumer Price Index (CPI).

In practice, the swap payments are netted out and one party makes a net payment to the other at maturity. For example, if the fixed rate on the swap is 2% p.a. and the actual inflation rate exceeds that value then the inflation receiver will be paid the excess by the inflation payer.

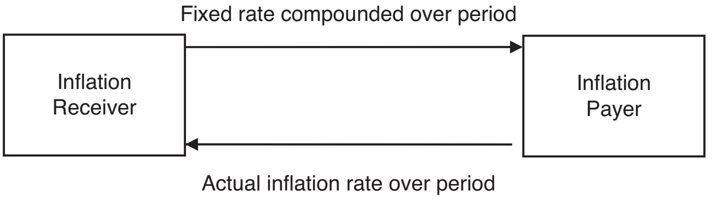

Figure 6.6 Zero coupon inflation swap

CHAPTER SUMMARY

A standard single-currency interest rate swap (IRS) is a bilateral legal agreement made directly between two parties to exchange cash flows on regular dates based on a fixed and a floating rate of interest. Normally payments are made in arrears and the floating reference rate is LIBOR. The first floating payment is known when the contract is agreed. Thereafter it will depend on future LIBOR settings. There is a potential credit risk on swaps. However this is reduced by the use of credit management techniques such as exchanging collateral.

IRS rates are quoted by dealers working for major banks and securities houses. For single-currency deals the rates are typically quoted in terms of the fixed rates versus LIBOR. The swap spread is the difference between the fixed rate on a swap and the yield on a reference government bond with a similar maturity. Swap spreads have been commonly taken in the market to reflect the general level of credit risk on financial institutions, although they can also be affected by other factors such as supply and demand.

A cross-currency interest rate swap is one in which the payment legs are in two different currencies. Normally the principal is exchanged at the start and re-exchanged at the same FX rate at maturity. A company that has an advantage in borrowing in a particular market can raise funds in that market and use a swap to change the nature of its liabilities, with the possibility of reducing its overall borrowing costs.

An inflation swap allows an organization such as a pension fund or insurance company to hedge its exposures to rising inflation rates.

7
Equity and Credit Default Swaps

INTRODUCTION TO EQUITY SWAPS

An equity swap is the over-the-counter answer to index and single stock futures. In a standard contract:

- two parties agree to exchange cash flows at regular intervals over an agreed period of time;
- at least one payment leg is based on the change in the value of an equity index or a specific share.

If the deal is a **total return swap** then the equity leg payment includes a sum of money representing dividends on the underlying shares. The return leg can be based on a fixed or a floating interest rate or on another equity index. In some structures the notional is fixed over the life of the swap and in other cases it varies. Payments are normally made monthly, quarterly, semi-annually or annually. The typical **tenor** (maturity) is one to three years.

Equity swaps can be more risky than interest rate swaps because the change in the value of the underlying index or stock can be *negative*. If this happens the party *receiving* the equity return has to pay its counterparty for the fall in the value of the underlying shares. Figure 7.1 shows the growth of equity forward and swap contracts. The June 2009 figure also shows how this was affected by the aftermath of the 'credit crunch' which started in 2007/8.

One possible equity swap application occurs when a company owns a block of shares in another firm (this is sometimes known as a **corporate cross-holding**) which it would like to 'monetize', i.e. to sell for cash.

However, the company wishes to retain the economic exposure to changes in the value of the shares for some time period. The company sells the shares and enters into an equity swap in which it receives the return on the shares paid in cash on a periodic basis. The next section provides an example of such a case.

EQUITY SWAP CASE STUDY

Suppose that a European company owns a block of 100 million shares in another firm. The shares are worth one euro each, so the total value of the holding is EUR 100 million.

The firm sells the shares to a bank, with which it also enters into a one-year equity swap. The notional principal is set at the outset at EUR 100 million, although this will be reset later depending on the changing value of the shares. In the swap:

- the bank pays the company the total return on the block of shares (capital gains or losses plus dividends) on a quarterly basis;
- in return, the company pays Euribor on a quarterly basis.

Euribor® (Euro Interbank Offered Rate) is a key reference rate for short-term lending in euros. It is sponsored by the Brussels-based European Banking Federation (FBE) and the Financial Markets Association (ACI).

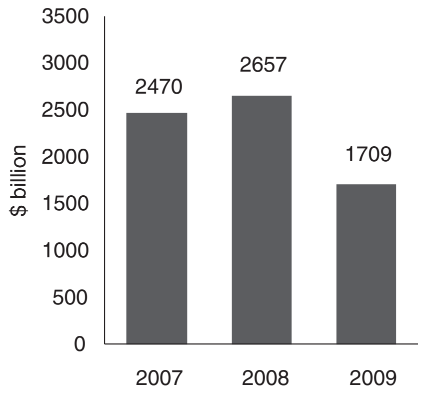

Figure 7.1 Notional amounts outstanding at mid-year on equity-linked swaps and forwards
Source: Based on data published by Bank for International Settlements available from www.bis.org

The quarterly payments on the swap deal are illustrated in Figure 7.2.

First swap payment

There will be four payments on the swap, the first being due three months after the start date. The Euribor rate for that first payment is fixed at the start of the contract.

Suppose that it is set at 4% p.a. or 1% for the quarter, so that the company will owe the bank EUR 1 million on the interest rate leg. Suppose also that on that first payment date the shares are now worth EUR 102 million. The bank then owes the company EUR 2 million for the increase in the value of the shares from the starting level of EUR 100 million. Assume that there are no dividends that quarter. Then all the payments are as follows:

- The company owes an interest payment of EUR 1 million.
- The bank owes EUR 2 million for the increase in the value of the shares.
- The payments are netted out and the bank pays the company EUR 1 million.

The notional principal and the Euribor rate are now *reset* to help calculate the cash flows due on the second quarterly payment date (six months after the start date). For simplicity we will assume that the Euribor rate is unchanged at 4% p.a. The notional principal value is reset to EUR 102 million, the current value of the shares.

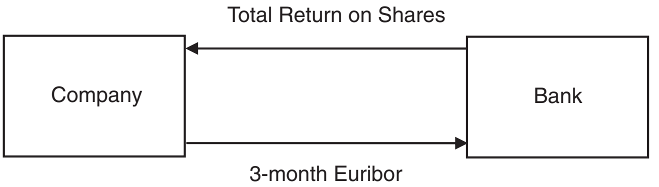

Figure 7.2 Equity swap payment legs

Second swap payment

Suppose that on the second payment date the shares are now worth EUR 99 million. No dividends have been paid during the quarter. Then the payments due on the swap for that quarter are calculated as follows:

- The company owes 1% of EUR 102 million in interest which is EUR 1.02 million.
- The company also owes EUR 3 million for the *fall* in the value of the shares from a level of EUR 102 million.
- The company pays the bank a total of EUR 4.02 million.

After this payment the swap notional is reset to EUR 99 million to help establish the third payment. The Euribor rate for the quarter is also reset.

Economic exposure

In summary, if the shares increase in value during a quarter, the bank pays the company for the increase. If the shares fall in value the company pays the bank. This replicates the economic exposure the company would have if it actually retained the shares.

Floating and Fixed Notional Equity Swaps

A floating or resetting notional swap such as the one just described replicates an exposure to a *fixed number* of shares. It is also possible to agree to fix the notional on an equity swap throughout the life of the contract. A fixed notional equity swap replicates an exposure to a *fixed value* of shares, such that if the share price rose or fell the investor would sell or buy shares to maintain a constant allocation.

OTHER APPLICATIONS OF EQUITY SWAPS

Equity swaps are versatile tools and have many applications for companies, banks and institutional investors. Because they are over-the-counter deals negotiated directly between the two parties, they can be tailored or customized to suit the needs of clients. A dealer will normally agree to pay the return on almost any basket of shares, provided some means can be found to hedge or at least to mitigate the risks on the transaction.

This can be useful, for example, for an investor who wishes to gain exposure to a basket of foreign shares but faces certain restrictions on ownership. A swap dealer will agree to pay the return on the shares (positive and negative) every month or every three months for a fixed period of time. In return, the investor will pay a floating or fixed rate of interest applied to the notional principal. The deal can be structured such that all the payments are made in a familiar currency such as the US dollar or the euro.

In this kind of case, it is possible that if the investor actually bought the underlying shares then, as a foreigner, the dividend income would be taxable. If so, the investor can enter into an equity swap with a dealer who is not subject to the tax or can reclaim it. The dealer borrows money to buy the shares, and in the swap the dealer pays the total return on the shares to the investor, including gross dividends. In return the investor pays a funding rate which the dealer uses in part to service the loan and in part to make a profit on the transaction.

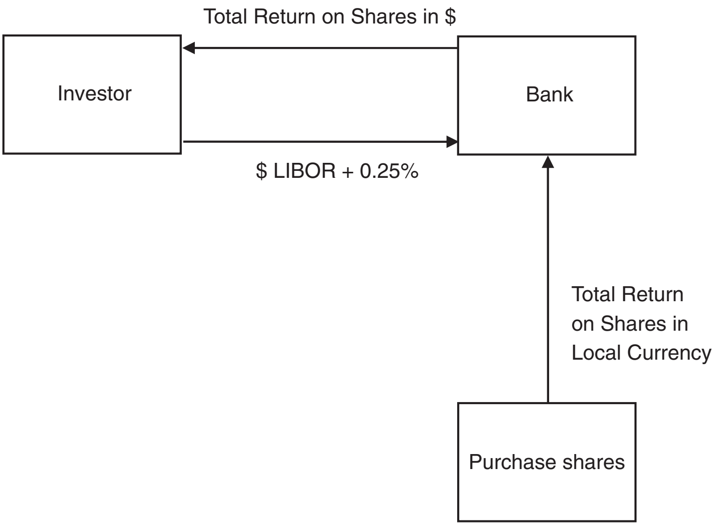

Figure 7.3 Equity swap payments including gross dividends

Total return equity swap

The series of transactions involved in this type of deal is illustrated in Figure 7.3. In this swap the bank pays the total return on the shares to the investor in US dollars. The investor pays US dollar LIBOR plus 0.25% p.a.

The bank borrows money to buy the shares and uses the dollar LIBOR payments from the swap to help pay the interest on the loan; assuming that it can borrow at LIBOR it can make 25 basis points (0.25%) p.a. on the deal.

It will need this, not just to make a profit, but also because its hedge is unlikely to be perfect and it will have to manage the risks. For example, although the bank has agreed to pay over the return on a specific basket of shares, it may decide to hedge by buying a *subset* of shares in the basket to save on transaction costs. It will also have to manage the currency translation, since it is making payments on the swap in dollars whereas the returns on the underlying shares will be achieved in local currency.

Taking Short Positions with Equity Swaps

It is easy for a client to take a 'short' position in a share or a basket of shares using equity swaps, i.e. to profit from a fall in the share price. The client agrees to pay the swap dealer any changes (positive and negative) in the value of a share. If the share price falls the client will receive payments from the dealer; if it rises the client will make payments to the dealer. Economically, this is the equivalent of a short position.

Of course it is also possible to take short (and long) positions in shares by trading equity index and single stock futures (see Chapter 5). The advantage of a swap is that it can be customized to meet the needs of the client.

On the other hand, futures are guaranteed by the clearing house, whereas swaps are over-the-counter (OTC) transactions and, as such, potentially carry counterparty default risk. As discussed previously, though, there is current debate about the extent to which OTC derivatives in future should be subject to clearing arrangements i.e. payments should be guaranteed by a clearing house. At the time of writing legislators are discussing proposals that the majority of OTC contracts should be standardized and cleared (see Chapter 20).

EQUITY INDEX SWAPS

In a standard equity index swap contract one party agrees to make periodic payments based on the change (positive or negative) in the value of an equity index. In return it receives a fixed or a floating rate of interest applied to the notional principal. The swap can be structured such that the notional principal remains constant over the life of the deal, or varies according to the changing level of the index.

Typical Indices used in Equity Swaps

These include the S&P 500 in the US, the DAX 30 index of top German shares, the CAC 40 in France, the Nikkei 225 index of major Japanese stocks and the FT-SE 100 index in the UK.

DAX equity index swap

Suppose a fund manager wishes to make a tactical asset allocation switch over the next year and to increase the fund's exposure to the German stock market. The desired exposure is EUR 100 million. Rather than selling off any existing assets, the manager decides to enter into an equity index swap on the DAX 30 index with a dealer. The fixed notional is EUR 100 million. The fund manager:

- pays three-month Euribor plus a spread on a quarterly basis for a year;
- receives the return on the DAX (positive or negative) on a quarterly basis for a year.

The payments on the swap are netted out. For example, suppose that in the first quarter of the deal the DAX rises by 5%. Then the manager is due a EUR 5 million cash payment on the equity leg of the swap. From this is deducted the interest payment due to the dealer.

However if the index *falls* in the quarter by (say) 5% then the manager would owe the dealer EUR 5 million on the equity leg. This is in addition to the payment due to the dealer on the interest rate leg.

The deal is illustrated in Figure 7.4. Note that the DAX is a **total return index** which means that it is assumed in the calculation that dividends are reinvested in additional shares.

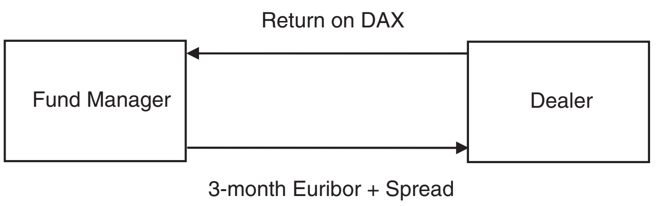

Figure 7.4 Payment diagram for DAX equity index swap

The swap deal could also be structured such that the fund manager pays a fixed rather than a floating rate of interest. It is easy to convert between these alternatives using a fixed-floating interest rate swap. (See Chapter 6 for details of interest rate swaps.)

HEDGING AN EQUITY INDEX SWAP

In the above example the dealer has in effect a *short position* in the DAX. If the index falls the dealer receives payments from the fund manager. If the market rises the dealer has to make payments to the fund manager.

Hedging Equity Swaps with Index Futures

The dealer could hedge this risk by buying DAX futures (see Chapter 5 for details of index futures contracts). Then if the index rises the payments the dealer has to make on the swap will be offset by profits on the futures contracts. The dealer would, however, have to buy futures contracts that best match the payment dates on the swap; and there is the risk that the contracts might be expensive, i.e. trading above their fair value. In practice it is all but impossible to construct a completely perfect hedge using futures contracts.

An as alternative to a futures hedge, the dealer could borrow money and buy a basket of German shares designed to track the DAX index. The dealer could use the Euribor-related receipts on the swap to service the interest payments on the loan used to buy the shares. The hedge is illustrated in Figure 7.5.

By using the hedge in Figure 7.5, the dealer has covered the risk that the DAX will rise. If it does, then the payments that have to be made to the fund manager on the equity leg of the swap will be matched by the profits on the shares bought in the hedge. Of course the reverse

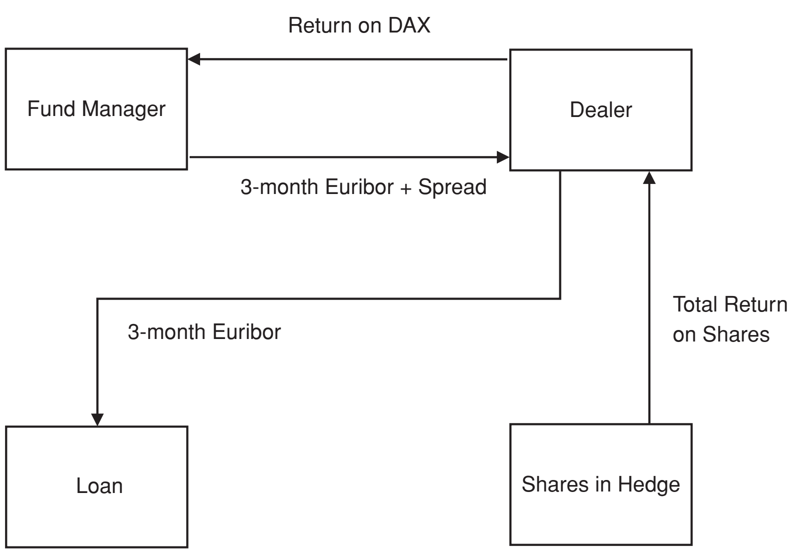

Figure 7.5 DAX equity swap hedged in the cash market

holds. If the DAX falls the payments received by the dealer on the equity leg of the swap will be matched by losses on the shares bought in the hedge.

Profit on the hedged swap

So how does the dealer make money? Look again at Figure 7.5.

- The dealer receives Euribor plus a spread (an additional amount of interest) on the interest rate leg.
- The assumption is that the dealer can borrow money at exactly Euribor to buy the shares in its hedge.
- So by entering into the swap and hedging in this way it has captured the spread over Euribor as its profit.

In practice, though, there are transaction costs that have to been taken into account in hedging a deal in this way, and also the potential counterparty risk on the swap, i.e. the risk that the fund manager may default on its obligations. To manage the counterparty risk the fund manager can be asked to deposit collateral. The hedge also assumes that the profits and losses on the portfolio of shares purchased exactly match changes in the DAX.

CREDIT DEFAULT SWAPS

In general terms, a **credit derivative** is a product whose value depends on the creditworthiness of an entity such as a corporation or a sovereign state. Sometimes it is based on a basket of such entities. The most popular product is the **credit default swap** (CDS).

According to the International Swaps and Derivatives Association (ISDA) the notional amount outstanding on CDS contracts reached over $62 trillion by year-end 2007. This exceeded the amount of actual debt worldwide. However by year-end 2008 the figure had fallen to $38.6 trillion. ISDA publishes standard legal terms for CDS contracts.

CDS Definition

A credit default swap is used to transfer credit risk between two parties. The buyer of protection pays a regular premium or spread to the seller of protection. In return, the protection seller makes a contingent payment if a credit event occurs affecting the reference entity specified in the contract. A swap can also be based on a basket of different reference entities. The most common maturity for CDS deals is five years.

In a CDS contract the **reference entity** specifies the corporation or other organization on which protection is bought and sold. The **reference obligation** is a security used to determine which assets of the reference entity can be delivered against the contract in the event of default; it is normally at the senior unsecured level of the capital structure (see box below).

A **credit event** is an occurrence defined in the CDS contract that triggers the contingent payment from the protection seller to the protection buyer, such as if the reference entity is declared bankrupt or defaults on certain debt obligations. The protection seller is sometimes said to be ‘long the credit risk’ because the position is economically equivalent to buying a debt asset which carries credit risk.

Capital Structure and Subordination

Subordination refers to the order in which a company's debt obligations are paid. The order is as follows.

- Senior secured debt
- Senior unsecured debt
- Senior subordinated debt
- Subordinated debt.

CREDIT DEFAULT SWAP: BASIC STRUCTURE

Figure 7.6 illustrates a basic single name CDS. The swap premium (spread) is paid at an agreed rate on regular dates. The market standard is for quarterly payments made on 20 March, 20 June, 20 September and 20 December. For example, if the swap principal is $10 million and the CDS premium is 2% p.a. then the quarterly payment is $50 000.

In effect, the CDS premium is the cost of purchasing insurance against default by the reference entity.

CDS physical settlement

Most CDS contracts are **physically settled**. This means that if a credit event occurs, the protection buyer has the right to deliver certain debt assets of the reference entity, called **deliverable obligations**, to the protection seller. In return, the protection seller will pay over the par or face value of those assets. In the CDS example in the previous subsection the payment would be $10 million.

The deliverable obligations can include bonds or loans or other forms of debt. However they must not be subordinated to the reference obligation that is specified in the contract.

If the CDS settlement process is triggered then the loss to the protection seller is the par value it has to pay for the assets that are delivered less their **recovery value**, i.e. any money that can be recovered from the reference entity on these assets. The CDS premium is paid by the protection buyer up to the date of the credit event.

CDS cash settlement

Some CDS contracts are **cash-settled**. If a credit event occurs the protection seller pays the buyer of protection a cash sum. For example, suppose the swap principal is $10 million and

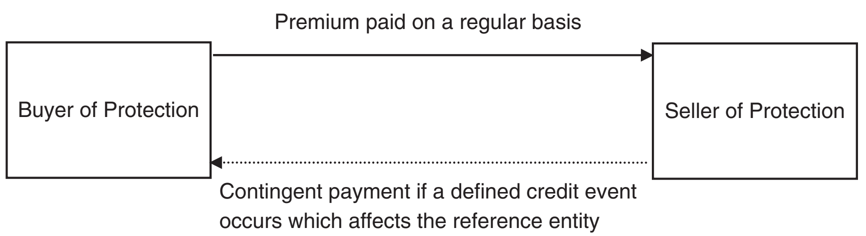

Figure 7.6 Credit default swap

a credit event occurs. The cheapest available eligible deliverable asset of the reference entity has a recovery value of $40 per $100 par value, i.e. 40%. The protection seller compensates the buyer for the loss of face value on the asset, a total of $6 million.

In some cases CDS contracts are based on a cash settlement amount which is predetermined in the contract. This is sometimes called a **binary CDS**.

Credit events

A single name CDS is designed to provide protection against the generic default risk on a particular reference entity. Since CDS contracts are over-the-counter deals (i.e. made directly between two parties) a wide range of credit events could be specified. In practice certain types of events have become common.

- **Bankruptcy**. The reference entity becomes insolvent.
- **Failure to Pay**. It fails to pay principal and interest on its debt obligations.
- **Debt Restructuring**. The structure of its debt is changed in a way that affects its creditworthiness, e.g. the maturity or coupon is changed.
- **Obligational Acceleration/Default**. It defaults and/or a debt obligation becomes due before the maturity date originally scheduled.
- **Repudiation/Moratorium**. It renounces its debt obligations and refuses to pay.

CREDIT DEFAULT SWAP APPLICATIONS

Perhaps the most obvious use of a CDS occurs when an investor or a commercial bank buys protection against losses on debt assets such as bonds and loans. In effect, the CDS provides a form of insurance, at the cost of paying the premium.

It is important to be selective here. An investor that covers *all* the default risk on a portfolio of debt securities using CDS contracts will be left with a return close to that on Treasuries (in practice it will probably be rather less than this because of transaction costs).

Credit default swaps are also invaluable for traders and hedge funds. It allows them to take a view on changes in the credit risk of borrowers without having to trade in physical debt securities. A standard CDS is an **unfunded** structure which means that, unlike buying an actual bond, an investor does not have to make an initial payment (although the investor may have to deposit collateral as a guarantee of good faith).

Taking a View on Credit Risk

A trader thinks that the creditworthiness of a corporation (the reference entity) is likely to deteriorate. The trader buys protection using a CDS and pays a premium of 1% p.a. If the credit risk on the corporation does increase the trader will then be able to *sell* protection on the same reference entity and earn a higher level of premium. Alternatively, if a credit event occurs, the trader can purchase the reference entity's bonds cheaply in the market, deliver them against the CDS contract and receive their full par value.

CDS contracts can have the additional advantage that they can be highly liquid at certain maturities. They also allow traders to take views on default risk over maturities that are not available with the underlying bonds.

Finally, financial institutions such as insurance companies can earn additional income and also diversify their current activities by selling protection on CDS contracts. The danger is that losses can snowball if the level of defaults rises. The US insurance giant AIG Inc. had to be bailed out by the US government in September 2008 because of losses on CDS deals and other types of insurance written to protect banks against losses on loans. As discussed in Chapter 1, the US authorities decided to rescue AIG because of the systemic risk to the financial system if it failed to meet its obligations.

Greek Financial Crisis 2010

In March 2010 German Chancellor Angela Merkel condemned the use of credit default swaps transactions to bet against Greek government bonds. Others argued that Greece's financial crisis was caused by fundamental economic and fiscal problems, in particular its excessive borrowing; and pointed out that trading in CDS contracts was much less significant than trading in the underlying Greek government bonds.

CREDIT SPREADS

The periodic premium paid on a CDS is related to, but not normally exactly the same as, the **credit spread** on cash bonds issued by the referenced entity. The credit spread on a bond is the additional return that investors can earn on that asset above the return available on assets (such as Treasury bonds) that are taken to have little or no risk of default. A **cash bond** is the market's way of talking about actual debt securities issued by corporates and governments rather than the derivative products whose values are derived from such underlying assets.

For example, suppose a five-year dollar bond issued by a company pays a return of 5% p.a. and the return on five-year US Treasury bonds is 4% p.a. Then the corporate bond's credit spread is 1% p.a. (100 basis points). The size of the spread depends on how likely it is to default. It also depends on other factors such as the **recovery rate** if it does default – how many cents in the dollar investors can recover from the corporate issuer.

Bonds issued by secure organizations with many assets tend to trade on low spreads. Junk bonds issued by risky entities tend to trade on high spreads.

The relationship between default risk and the compensating returns demanded by lenders was well understood by Adam Smith. He states the point succinctly in *The Wealth of Nations* (Book I, Chapter IX):

> The lowest ordinary rate of interest must . . . be something more than sufficient to compensate the occasional losses to which lending, even with tolerable prudence, is exposed. Were it not more, charity or friendship could be the only motives for lending.

THE CDS PREMIUM AND THE CREDIT SPREAD

In the market jargon, the seller of protection in a CDS is **long the credit**, i.e. assumes the credit risk on debt issued by the referenced entity. As a result, the seller of protection should be paid a premium that reflects the default risk on that asset and the potential recovery rate – i.e. one that is related to the credit spread.

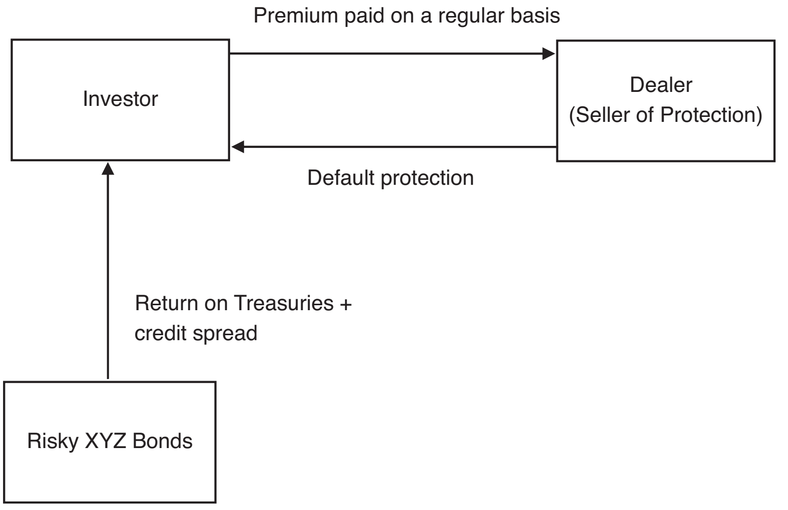

Figure 7.7 Owning risky bonds plus buying protection on a CDS

To see why this is so, suppose that an investor owns risky bonds issued by XYZ Inc. The investor decides to insure against default by buying protection from a CDS dealer. The investor's position is shown in Figure 7.7.

Since the investor in Figure 7.7 has eliminated credit risk, the total return he or she should earn after buying protection via the CDS should be around the risk-free rate, i.e. the return on Treasuries. That means the swap premium payable should roughly cancel out the credit spread earned on the XYZ bonds.

Cheapest-to-deliver (CTD) option

In theory, then, the premium on a CDS should be close to the credit spread earned on a position in the underlying cash bond. In practice, however, the picture is complicated by differences between the way that CDS contracts operate compared to investments in cash bonds. For example, the seller of protection in a CDS may receive one of a number of debt securities at the choice of the buyer of protection, who will tend to choose the cheapest. This creates a so-called **cheapest-to-deliver option** which has value.

Furthermore CDS contracts can be more liquid than cash bonds, especially at standard maturities and with frequently traded names. This will affect the premium at which they trade. In developed markets now 'the tail wags the dog' since CDS spreads may be used to determine the prices and yields of the underlying cash bonds.

Counterparty risk and CDS contracts

CDS contracts also carry a potential counterparty risk. This is because they are made directly between two parties, one of which may fail to perform its duties. For example, if a credit event occurs the seller of protection may be unwilling or unable to proceed with the settlement process. As discussed previously, regulators have encouraged dealers to increase the use of central clearing arrangements for CDS deals (see also Chapter 20).

PRICING MODELS FOR CDS PREMIUM

There are a number of ways in which the fair premium on a CDS deal can be established. One is by modelling the probability of default on the debt asset referenced in the contract, based on its credit spread or on the historical behaviour of assets of that credit quality. The ratings agencies publish historical default rates and recovery rates on different classes of assets with different credit ratings. They also publish **transition matrices** which provide historical data on the occurrence of ratings downgrades on assets with similar credit qualities.

The case below gives a very simple example of how CDS pricing can be tackled using default probabilities and recovery rate values. It is based on the idea that the CDS premium should compensate for expected losses.

Establishing the CDS premium

Suppose that an investor owns bonds issued by XYZ Inc, and buys default protection from a CDS dealer. The bonds mature in one year and have a par value of \$1 million. Assuming there is no default, the \$1 million par value will be paid by XYZ to the investor in one year. However if XYZ defaults the CDS dealer will have to buy the bonds from the investor and pay the investor the \$1 million. What is a fair premium for the CDS deal?

Suppose the dealer reckons that the probability of default is 2% and the recovery rate in the event of default will be 40%. This means that if default occurs the dealer will have to pay \$1 million for the bonds, which will then only be worth the amount that can be recovered from XYZ's assets, i.e. 40% of \$1 million or \$400 000.

The dealer's loss given default will be \$600 000. The chance of making that loss is estimated to be 2%. So the **expected loss** to the CDS dealer is $\$600\,000 \times 2\% = \$12\,000$. Therefore the dealer should charge the investor a CDS premium of about \$12 000 to compensate for its expected loss on the deal. On \$1 million this is 1.2%.

INDEX CREDIT DEFAULT SWAPS

It is also possible to trade an **index** based on CDS premiums. In Europe the key product is the iTraxx Europe index maintained by Markit Group Limited, which is based on the CDS premiums on 125 top European investment grade names or reference entities. Each name comprises 0.8% of the index.

The composition of the index is reviewed or 'rolled' every six months in March and September based on the most actively traded CDS names established through dealer polls. A new series is created based on the particular names specified in that portfolio, which can then be used as the basis for over-the-counter index CDS deals. (Markit also owns the Markit CDX family of indices, covering North America and emerging markets.)

Index CDS example

Suppose at the issue of a given series a trader takes EUR 25 million five-year iTraxx Europe credit exposure in unfunded form from a market maker (i.e. sells protection in a CDS transaction). The premium is 1% p.a. This is based on the CDS premiums on the 125 names in the index. The deal will be physically settled.

The market maker pays the trader 1% p.a. on a quarterly basis on EUR 25 million for five years. If no credit events occur that affect the names in the index, the market maker will pay the premium until maturity.

However if a credit event *does* occur during the five years affecting one of the names, then the trader will have to make a payment to the market maker. As stated above, each name comprises 0.8% of the index. The payment will therefore be:

$$\text{EUR 25 million} \times 0.8\% = \text{EUR 200 000}$$

In return, the market maker delivers EUR 200 000 par value of deliverable bonds of the reference entity that defaulted. The notional on the index CDS deal is then reset to EUR 24.8 million. The market maker continues to pay 1% on this value until maturity, unless further credit events occur affecting other names in the index.

Applications of index CDS deals

Banks and institutional investors can use an index CDS deal to hedge the risk on a portfolio of loans or bonds. Traders can use the product to speculate on a basket of names as represented by the index components. They can also construct various **spread** or relative value trades in which they buy one index and sell another.

It is normally cheaper in terms of transaction costs to trade an index than to buy CDS contracts on the individual names in the index. It is also possible to trade options on CDS indices, otherwise known as **swaptions**. The owner of a swaption has the right but not the obligation to enter into a CDS contract as the buyer or as the seller of protection at a predetermined price.

BASKET CREDIT DEFAULT SWAPS

Generally, in an ***n**$^{th.}$* **to default** basket swap the payment from the protection seller to the buyer is triggered by the default of the $n^{th.}$ reference entity in the basket. The swap then terminates. The protection buyer pays a regular premium to the seller until maturity or until a credit event occurs affecting the $n^{th.}$ asset. Contracts can be cash-settled or physically settled. The most common contract types are discussed below.

FTD basket default swap

In a first-to-default (FTD) deal $n = 1$. That is, the settlement process is triggered by the first name in the basket to default.

For example, suppose a trader sells protection on an FTD basket of five corporations. The principal is $10 million and the maturity is five years. The protection buyer pays a premium of 200 bps. or 2% p.a. If one of the names defaults the protection seller has to take delivery of $10 million par value of bonds issued by that name and pay the par value to the buyer of protection. The FTD deal then terminates. The premium is paid by the buyer of protection up to termination or maturity, whichever is the sooner. The deal is illustrated in Figure 7.8.

Establishing the premium on an FTD swap is a complex matter and requires the use of a mathematical model. Some aspects are more straightforward than others. For example, other things being equal, the premium will tend to increase the greater the number of names in the basket and the lower their credit quality. The more names that are included, the more likely it is that one will default over the life of the FTD deal.

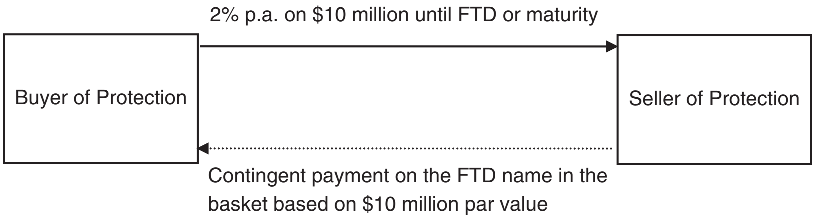

Figure 7.8 FTD credit default swap

However, pricing an FTD also requires an assumption about the so-called **default correlation** between the various assets in the basket. This measures their tendency to default together and to survive together.

STD basket default swap

In a second-to-default (STD) basket default swap $n = 2$. Nothing is paid for the first credit event. Then the deal becomes an FTD on the remaining names in the basket.

In an STD, high default correlation actually tends to *increase* the risk to the seller of protection, because if one entity defaults another is likely to follow suit. This increases the premium. By contrast, low default correlation tends to reduce the STD premium because the names in the basket are less likely to default together. Intuitively, they are affected by different market factors.

CHAPTER SUMMARY

An equity swap is an agreement between two parties to exchange cash flows on regular future dates, where at least one of the payment legs depends on the value of a share or a portfolio of shares. The notional principal on the deal can be fixed or floating. Traders and investors can replicate long and short positions in shares by using equity swaps. In an equity index swap one payment leg is based on a stock market index such as the S&P 500. A deal can be hedged by trading index futures or by buying or shorting the underlying shares in the index.

In a credit default swap (CDS) the buyer of protection pays a premium to the seller of protection. The protection buyer receives a contingent payment depending on whether or not a defined credit event occurs which affects the referenced entity specified in the contract. The referenced entity can be a corporation, a financial institution or a government. Credit events can include bankruptcy or default on debt obligations.

The CDS premium depends on the probability that a credit event will occur and also on any money that can be recovered from the referenced entity if a credit event does occur. Buyers of protection include fund managers and commercial banks seeking to reduce the level of credit risk on portfolios of bonds or loans. Sellers of protection include dealers in banks and insurance companies.

In an index default swap the protection buyer is paid by the seller of protection if one or more of the reference entities or 'names' in the index defaults. By contrast, in a first-to-default (FTD) basket credit default swap a payment to the protection buyer is triggered by the first name in the basket to default, after which the contract terminates.

Chapter 19 discusses further uses of credit default swaps in creating structured securities and in securitization.

8

Fundamentals of Options

INTRODUCTION

Chapter 1 explained that options on commodities such as rice, oil and grain have been in existence for many years. Options on financial assets are more recent, although they have expanded rapidly since the 1980s.

This chapter introduces fundamental option concepts. It takes a 'building block' approach and describes the basic option strategies that are applied in different combinations in later chapters. It explains the key 'jargon' expressions used in the options market – call and put; strike price; expiry date; premium; intrinsic and time value; in-, at- and out-of-the-money; break-even point; and so on. These concepts are illustrated with practical examples. The chapter shows the payoff profiles for four basic option strategies – long a call, short a call, long a put, short a put. These are compared with the profits and losses achieved by buying or selling underlying shares.

DEFINITIONS

The buyer of a standard or 'vanilla' financial option contract has the right but not the obligation:

- to buy (call option) or to sell (put option);
- an agreed amount of a specified financial asset, called the underlying;
- at a specified price, called the exercise or strike price;
- on or by a specified future date, called the expiry date.

For this right the buyer of an option pays an up-front fee called the **premium** to the writer of the contract. This is the most money the buyer can ever lose on the deal. On the other hand the writer of an option can face virtually unlimited losses (unless a hedge is put in place). This is because it is the buyer who decides whether to exercise (take up) the option.

Exchange-traded options are mainly standardized, but settlement is guaranteed by the clearing house associated with the exchange. Over-the-counter (OTC) option contracts are agreed directly between two parties, one of which is normally a bank or securities trading house. As a result the contracts can be customized to meet the needs of specific clients. However they cannot be freely traded and there is a potential default risk – the risk that the counterparty may fail to fulfil its obligations.

As discussed previously, initiatives have now been launched to control the credit risk on OTC derivatives generally, in the wake of shocks such as the collapse of the giant investment bank Lehman Brothers in September 2008.

TYPES OF OPTIONS

There are two main varieties of option contract.

- **Call Option**. The right but not the obligation to buy the underlying asset at the strike price.
- **Put Option**. The right but not the obligation to sell the underlying asset at the strike price.

A so-called **American-style** option can be exercised on or before expiry. A **European-style** option can only be exercised on the expiry date of the contract. In fact, these labels are historical and have nothing to do with where options are actually dealt. Most options traded on exchanges around the world are American-style. OTC options, regardless of where they are created, are often European-style. Because an American option confers additional rights, it is worth at least the same as the equivalent European contract.

Bermudan Options

For those who like the flexibility of early exercise but who do not wish to pay the full cost of an American option, the market has created alternative contracts known as Bermudan options. These can be exercised on specific dates up to expiry, such as once a month.

In practice relatively few options are ever exercised. A trader who has bought an exchange-traded option can simply sell it back through the exchange if it becomes more valuable, rather than actually exercising the contract. Options are bought and sold as assets in their own right and many traders try to profit from the difference between the purchase and the sale price. And in any event most contracts expire worthless.

BASIC OPTION TRADING STRATEGIES

The following sections explore the return and risk characteristics of the four basic option trading strategies:

- Long call
- Short call
- Long put
- Short put.

This section begins with a call option. The details of the contract are specified in Table 8.1.

The buyer of the option has the right but not the obligation to buy 100 XYZ shares at a fixed strike or exercise price of $100 each, on or before the expiry date in one year. For this right the buyer has to pay an up-front premium of $10 per share to the writer of the contract.

Table 8.1 Call option contract

Type of option:	American-style call
Underlying share:	XYZ
Number of shares:	100
Exercise price:	$100 per share
Expiry date:	One year from today
Current share price:	$100
Option premium:	$10 per share

Intrinsic value

The option in Table 8.1 is said to be **at-the-money**. This means that the strike price and the current or cash market share price are exactly the same. An at-the-money option has **zero intrinsic value**.

For an American option, intrinsic value is defined as any money that can be realized by immediately exercising the option. It is either zero or positive, because the buyer of an option is never obliged to exercise the contract when this involves making a loss. The call in Table 8.1 has zero intrinsic value because it provides the right to buy a share for \$100 that is currently worth \$100. There is no money to be made by exercising the option at the moment.

On the other hand if the current share price on the market was \$120 then a call with a strike of \$100 would be **in-the-money** (ITM). It would have \$20 intrinsic value per share. The holder of the call could exercise the right to buy the share at the strike price of \$100 and immediately resell the share on the cash market at \$120. Ignoring funding and transaction costs, the value realized from exercising the contract would be \$20 per share.

If the current share price was \$80 then a \$100 strike call would be **out-of-the-money** (OTM) with zero intrinsic value. The share price would have to rise by more than \$20 before the option would be worth exercising.

Time value

The option in Table 8.1 has zero intrinsic value. However the option still has value, which is why the writer charges a premium. The value of an option over-and-above any intrinsic value it has is called **time value**.

The option in Table 8.1 has time value because (as the name suggests) there is time remaining to expiry. In this example it has one year to expiry. The time value reflects the chance that the option *may* move in-the-money before it expires and be worth exercising. It also reflects the fact that the buyer of the call can gain by depositing the strike price and earning interest until the option is exercised.

Total option value

The total option value equals intrinsic value plus time value. To put it another way, subtracting the intrinsic value from an option premium establishes the time value component. Since the option in Table 8.1 has zero intrinsic value, the time value must be \$10 per share. That is, the premium in this example consists entirely of time value. It is paid for the chance or probability that the option *may* be worth exercising at some point over the next year before it expires.

LONG CALL: EXPIRY PAYOFF PROFILE

A useful way to look at an option strategy is in terms of its profit or loss profile at expiry, net of the initial premium paid. At expiry there is a simple decision for the buyer of an option to make – either the contract is exercised or it is discarded as worthless. Put another way, an option at expiry has positive intrinsic value if it expires in-the-money; it has zero intrinsic value if it expires out-of-the-money or at-the-money. It has no time value because it has expired.

Suppose a trader buys the at-the-money call in Table 8.1. The premium paid to the writer is \$10 per share. The strike is \$100 per share. This is a **long call** position. It profits from a

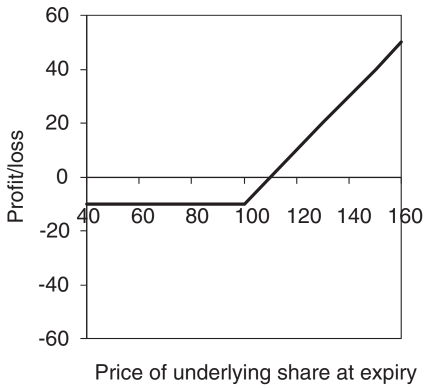

Figure 8.1 Expiry payoff profile for a long call

rise in the value of the underlying share. To keep things simple the following analysis ignores transaction and funding costs, including the fact that the premium is paid up-front whereas the decision on whether to exercise the option is taken later. With this proviso, Figure 8.1 shows the payoff (per share) for different levels of the underlying at expiry.

At expiry the owner of the call option will only exercise the contract when the underlying price is above the strike price. For example, if the share is trading at $90 at expiry then the holder of the call will not take up the right to buy the share at a fixed price of $100: it could be purchased more cheaply in the cash market. If the option is not exercised the loss is the initial $10 premium. However if the underlying share is worth *more* than $100 at expiry then it makes sense to exercise the call. It has positive intrinsic value.

Break-even Point

The break-even point on the long call is reached when the share is trading at $110. At that level the $10 initial premium is exactly offset by the $10 intrinsic value of the long call. The call confers the right to buy a share at $100 that is worth $110 in the cash market and $10 could be realized by exercising the option.

Downside and upside

In the jargon of the markets, a long call position has **limited downside risk** but **unlimited upside**. In other words, the maximum loss is restricted to the initial premium paid, because there is no obligation to exercise a contract that expires out-of-the-money. On the other hand there is no limit to the profit that the buyer of a call option can make. The underlying share price could (in theory) rise to any level and the holder of the call has the right to buy the share at the fixed strike price.

Long call and cash position compared

Buying a call probably seems like a very attractive proposition (limited risk, unlimited return). However the initial premium acts as something of a dead weight on the profitability of the

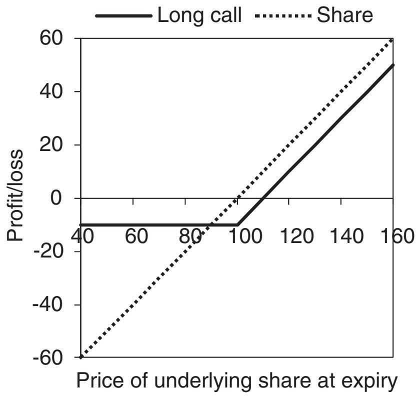

Figure 8.2 Long call versus a long position in the underlying share

position. For example, rather than buying the above at-the-money call, the trader could simply buy the underlying share in the cash market at \$100. Then if the share price rose to \$110 the trader would make a \$10 profit, while because of the initial premium paid the option position would simply break even.

Figure 8.2 compares the expiry profit and loss profile of the long call against a position in the underlying share purchased in the cash market at \$100.

One factor which Figure 8.2 ignores is that the initial outlay on the long call is much less than the cost of buying the actual share. This means that the option position has the benefit of **leverage**. For example, if the share price doubled the call would be worth \$100 intrinsic value per share. This would produce a very large percentage return on the initial \$10 premium per share paid to buy the contract.

SHORT CALL: EXPIRY PAYOFF PROFILE

This section looks at the \$100 strike call in Table 8.1 from the perspective of the writer of the contract. The initial premium received is \$10 per share. This is the most money the writer can ever make out of the deal. If the option expires out-of-the-money the buyer will not exercise the contract and the premium is a profit for the writer. However if it expires *in-the-money* the buyer will exercise and has the right to purchase shares at \$100 each which have a higher value in the cash market.

Figure 8.3 shows the payoff profile of the short call position at expiry. This is sometimes called a **naked short option** position because it is unhedged. If the buyer of the call exercises the contract the writer has to buy shares in the cash market at their current value and deliver the shares at a fixed price of \$100 each. In practice, writers of call options normally hedge their risks, sometimes through offsetting options positions, sometimes by purchasing the underlying asset.

A naked short call is dangerous because it has limited upside (limited to the initial premium received) and potentially unlimited downside.

Some option contracts are **cash-settled** rather than being settled through the physical delivery of the underlying asset. In this case the writer of the contract pays any intrinsic value over to the buyer at expiry. For example, if the strike of a call option is \$100 and the underlying

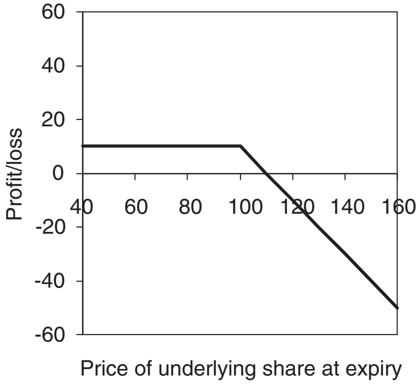

Figure 8.3 Expiry payoff profile for short call struck at $100

share is worth $120 at expiry the writer will pay $20 to the buyer of the call. If the share is worth (say) $80 at expiry the writer will pay out nothing.

LONG PUT: EXPIRY PAYOFF PROFILE

This section explores the position of the buyer of a put option, i.e. a **long put**. The contract is specified in Table 8.2. In this contract the strike is $100. The buyer of the put has the right (not the obligation) to sell 100 XYZ shares at $100 each. The premium is $10 per share. A long put is a ‘bear’ position: it makes money when the underlying price falls. The maximum loss is the premium paid to the writer of the contract at the outset.

The contract in Table 8.2 is an **at-the-money** put option since the spot (cash) price is the same as the strike price. The contract has zero intrinsic value: no money can be realized through immediate exercise.

On the other hand if the current share price on the market was (say) $80 then a put with a strike of $100 would be **in-the-money** (ITM). It would have $20 intrinsic value per share. The holder of the put could buy the share for $80 in the cash market and then exercise the right to sell that share for $100 via the option, earning $20 through exercise. Of course if an option is already in-the-money when it is bought this will be reflected in the premium cost.

Table 8.2 Put option contract

Type of option:	American-style put
Underlying share:	XYZ
Number of shares:	100
Exercise price:	$100 per share
Expiry date:	One year from today
Current share price:	$100
Option premium:	$10 per share

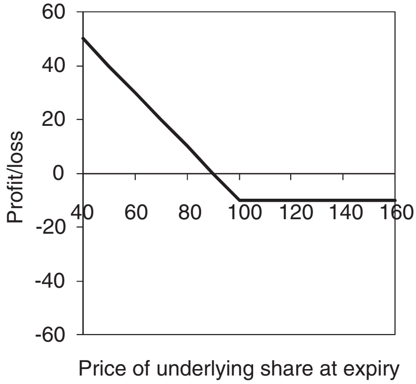

Figure 8.4 Expiry payoff profile for a long put

Long put expiry payoff profile

Figure 8.4 shows the profit and loss profile of the above long put at expiry, net of the initial premium paid, on a per share basis. If the underlying is trading *below* the $100 strike at expiry it makes sense to exercise the option – it has positive intrinsic value. The break-even point is reached when the share is trading at $90. Then the $10 profit from exercising the put offsets the $10 premium. If the underlying is trading *above* the $100 strike at expiry the option expires worthless, and the loss on the long put is the $10 premium.

Long put versus shorting the stock

A long put is a bear position, but it is far less risky than shorting the underlying share. The potential losses to a short seller are theoretically unlimited since the 'short' has to buy the shares back and return them to the original owner at the prevailing market price – which might be far above the sale price. Figure 8.5 compares the payoff on the $100 strike long put with a position in the underlying share sold short at $100.

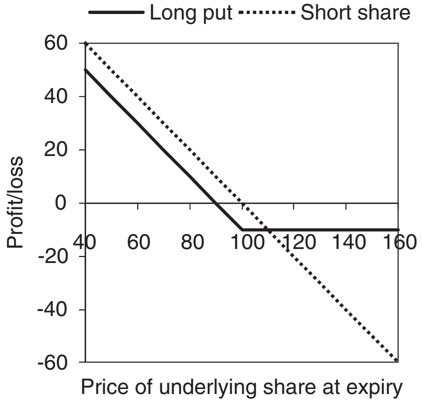

Figure 8.5 Long put versus a short position in the underlying

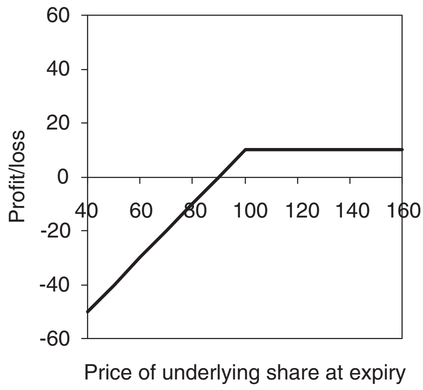

Figure 8.6 Expiry payoff profile for a short put

SHORT PUT: EXPIRY PAYOFF PROFILE

Figure 8.6 shows the payoff profile at expiry of the put option in Table 8.2, but this time from the writer's perspective. The strike is $100 per share.

The maximum profit for the writer of the put option (per share) is the premium of $10 and the maximum loss is $90. If the share price closes at or above the strike at expiry, the buyer of the option will not exercise the contract and the writer has made a $10 profit. On the other hand, if the share price is *below* $100 the owner of the put will exercise the contract.

The break-even point occurs when the share is trading at $90. At that level the writer will be sold a share for $100 that is worth $90 in the cash market, making a $10 loss, which is offset by the initial premium. Below $90 the position shows a net loss.

Figure 8.6 shows the payoff profile of a 'naked' short put option, that is, without a hedge in place. Given the risks on such a position, the writer will normally hedge the risks by trading other option contracts or by shorting the underlying – which will show a profit if the share price falls, to offset the losses on the put.

SUMMARY: INTRINSIC AND TIME VALUE

- The intrinsic value of an American call is zero or the current price of the underlying asset minus the strike, whichever is the greater.
- The intrinsic value of an American put is zero or the strike minus the current price of the underlying asset, whichever is the greater.
- Strictly speaking the strike of a European option should be compared with the **forward price** of the underlying at expiry, since the option can only be exercised (and the strike price paid) at expiry. In practice, many people ignore this factor and calculate intrinsic value on a European option using the current price of the underlying. With shorter-dated options the difference may not be very great.
- An option either has positive or zero intrinsic value. Intrinsic value by definition is never negative – the buyer of an option cannot be forced to exercise the option and make a loss on exercise.

Table 8.3 Summary of key option strategies

Strategy	Premium	Characteristic
Buy call	Pay	Right to buy the underlying at the strike price
Write call	Receive	Obligation to deliver the underlying if exercised
Buy put	Pay	Right to sell the underlying at the strike price
Write put	Receive	Obligation to take delivery of the underlying if exercised

- Intrinsic value can only be realized before expiry through exercising an option in the case of an American contract. However the current value of an option will reflect any intrinsic value it may have.
- Even if an option has no intrinsic value, if there is any time remaining until expiration and the price of the underlying asset can fluctuate, the option will have time value.
- From the perspective of the option writer, time value reflects the risk involved in potentially having to deliver an asset (short call) or take delivery of an asset (short put) at a fixed price.
- All other things being equal, the longer the time to the expiry of an option, the higher its time value. A long-dated option provides more profit opportunities for the owner than a short-dated option.
- The premium cost of an option consists of intrinsic value (if any) plus time value. To put it another way, subtracting the intrinsic value from the premium calculates the time value component.

Finally, Table 8.3 summarizes the characteristics of four basic option strategies considered in this chapter. Chapter 9 explores some key hedging applications of options.

9
Hedging with Options

CHAPTER OVERVIEW

Options can be combined together and with positions in underlying securities to construct many different trading strategies and risk management solutions. This chapter explores a basic option application, the **protective put**. This uses a put option to hedge against potential losses on a position in an underlying security.

A protective put can be combined with shorting a call, to construct a **collar** strategy. If the strikes of the put and the call are set at the right levels the premiums of the two options cancel out, and the strategy becomes a zero-cost collar. Alternatively, the protective put can be constructed using a nonstandard or 'exotic' option contract called a **barrier option**. This saves on premium, although the hedge ceases to operate in certain circumstances.

FUTURES HEDGE REVISITED

The case investigated throughout this chapter is that of an investor who owns a share currently trading at \$100. The investor is concerned about the possibility of short-term falls in the value of the share due to general turbulence in the equity markets.

The investor could, of course, *sell* the share and deposit the proceeds in the money markets, or switch into another financial asset. However this will incur transaction costs, and may also trigger tax liabilities. In addition, the investor may have built up the shareholding over time and may prefer not to switch simply because of short-term problems. Furthermore, if the investor does make a premature switch there is the danger of incurring an **opportunity loss** – that is, the loss of profits that would arise if the share price increased rather than fell.

Results of a futures hedge

The investor could hedge the exposure by selling single stock futures or entering into an equity swap contract (see Chapters 5 and 7). Then if the share price falls the investor will be compensated through gains on the futures or the swap. The disadvantage of this type of strategy is that the reverse would hold: profits on the share would be offset by cash payments the investor would have to make on the futures or the swap contract.

Figure 9.1 illustrates the results of a futures hedge. For simplicity this assumes that the futures is sold at the spot price of the underlying (in this case \$100).

PROTECTIVE PUT

Alternatively, the investor can set up a protective put strategy. This combines a long (bought) position in the underlying with a long (bought) put option on that asset. The combination is designed to provide what is called **downside risk protection** – that is, to hedge against short-term falls in the price of the underlying asset.

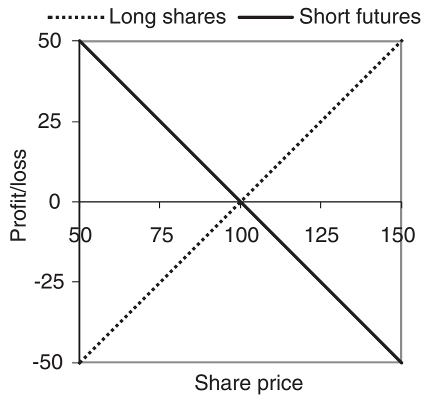

Figure 9.1 Short futures hedge against a long position in a share

If the put is a physically exercised contract then it can be exercised when the price of the underlying share falls below the strike of the option. The underlying is then sold at the strike price, eliminating any further losses.

If the put is cash-settled then any losses incurred on the share below the strike price are compensated for through cash payments received from the writer of the put option contract. A cash-settled option is useful for an investor who wishes to retain the share and who simply wishes to insure against short-term losses.

> **Advantages of the Protective Put**
>
> The advantage of covering the risks on a long position in a share with a put option is that the investor can achieve downside protection whilst still being able to benefit from increases in the share price.

Protective put example

In the case considered in this chapter the investor owns a share trading at \$100, but is concerned that the price may fall over the short term. Suppose the investor contacts a dealer and agrees to buy a three-month European put option on the share with a strike of \$95. The agreed premium is \$3.5 per share.

Figure 9.2 illustrates the profit and loss on the share and on the put at the expiry of the option. The figures are in dollars and for a range of different prices of the underlying at expiry. Note that in this and subsequent examples matters are simplified by ignoring the effects of the time value of money: in fact the premium would be paid up-front, whereas any payout from exercising the option would occur in three months' time. In addition, all the premiums quoted in this chapter have been rounded to simplify the break-even calculations.

Figure 9.2 shows the profit and loss on the share as a diagonal line cutting through the current share price of \$100. If the share price rises the investor will make a profit on the share; otherwise he or she will make a loss.

Figure 9.2 also shows the profit and loss on the bought put option at expiry. The maximum loss on the put is the \$3.5 premium. The contract will only be exercised at expiry if the

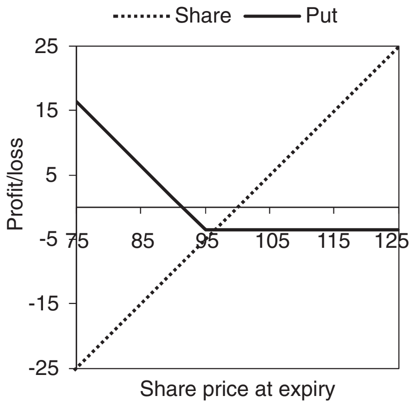

Figure 9.2 Payoff on the underlying share and on the put at expiry

share price has fallen below the $95 strike. At share price levels below the strike the put is in-the-money. The point at which the put (considered on its own) cuts through the zero profit and loss line is the strike minus the premium, that is at $\$95 - \$3.5 = \$91.5$.

Next, Figure 9.3 shows the **combination** payoff profile of the position in the share hedged with the $95 strike put option. For comparison it also shows the profit and loss for an unhedged position in the underlying share.

Maximum loss with protective put

In Figure 9.3 the maximum loss per share on the hedged position is $8.5. This is the combination of $3.5 premium on the put (which is a sunk cost at expiry and never recovered) plus the difference between the share price which started out at $100 and the $95 strike of the option. The put was initially struck out-of-the-money and the underlying can fall $5 before the protection it affords comes into effect.

If the put is cash-settled then any losses on the share at price levels below $95 will be compensated in cash by payments received from the writer of the option.

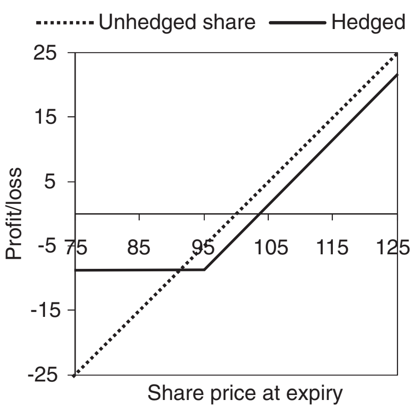

Figure 9.3 Hedge constructed with $95 strike put option

Other break-even levels

There are a couple of other reference points in Figure 9.3 that are of interest. What happens if the share price *rises* and the protection afforded by the put option is not required? The problem here is that the share price has to rise to $103.5 before the initial premium paid for the option is recovered. This contrasts with the unhedged position, where the position is in profit if the share price rises above $100.

Secondly, the hedged and unhedged lines in Figure 9.3 meet with the share price at $91.5. This is when both strategies (hedged and unhedged) lose $8.5. This would be a significant level for the investor. Provided the share price stays above $91.5 the investor is actually better off unhedged, i.e. without buying the put option.

Synthetic Call

Note that the hedged payoff profile in Figure 9.3 resembles that of a bought call on the underlying. This is a common feature of options. They can be assembled in many different combinations, often replicating (at least in some aspects) other option positions.

HEDGING WITH ATM PUT OPTION

Buying an out-of-the-money put to hedge the risk on a share is like buying a cheap insurance policy – the option is relatively inexpensive, but the protection level is not particularly good.

The investor could improve on this by buying an **at-the-money** put struck at the spot price of $100. However this would be more expensive. Suppose the premium cost for this option is $5.5 per share. Figure 9.4 illustrates the payoff profile at expiry on the combined hedged position (long the share, long the $100 strike put).

The maximum loss this time is better than before at $5.5 per share. However if the share price *rises* rather than falls, it would now have to rise to $105.5 at the expiry of the put to recover the higher option premium. The figures for the $95 strike put option were $8.5 and $103.5 respectively.

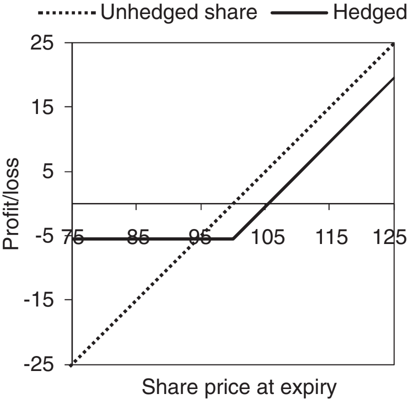

Figure 9.4 Hedge constructed with ATM put option

By buying an **in-the-money** put the investor could further reduce the maximum loss on the combined position (to a level converging on zero) whilst pushing out the price the share would have to rise to break even (to a level converging on infinity). In fact buying a deeply in-the-money put is really like establishing a short position in the underlying – there is a very high probability that the put will be exercised and the underlying stock sold.

COVERED CALL WRITING

Investors can generate additional income by selling a call option against a holding of shares. This is known as a **covered call** or buy-write strategy. The premium income also provides a 'cushion' against a fall in the share price.

To illustrate the strategy, this section takes the same case as before: an investor who owns a share currently worth \$100. This time the investor decides to explore selling a three-month out-of-the-money call struck at \$105 against this holding. The premium earned is \$4.5 per share. Figure 9.5 illustrates the profit and loss profile of the long position in the share and the short position in the \$105 strike call at the expiry of the option.

In Figure 9.5 the call payoff profile (considered on its own) cuts through the zero profit and loss line at the strike plus the premium, i.e. when the share is trading at $\$105 + \$4.5 = \$109.5$. At that level the investor will lose \$4.5 on the exercise of the short call, which eliminates the premium initially collected on the option.

Now Figure 9.6 illustrates the payoff profile of the **combined** position – long the share, short the \$105 strike call sold at a premium of \$4.5 per share. For comparison the original long position in the share is also shown.

Maximum profit on the covered call

In Figure 9.6 the maximum profit at expiry on the covered call strategy is \$9.5 per share, achieved when the share is trading at \$105. At \$105 the short call will not be exercised, and the investor retains the \$4.5 premium. In addition, the investor has made \$5 on the long position in the underlying share.

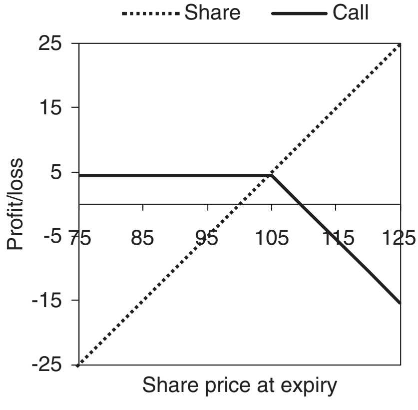

Figure 9.5 Long position in share and short OTM call at expiry

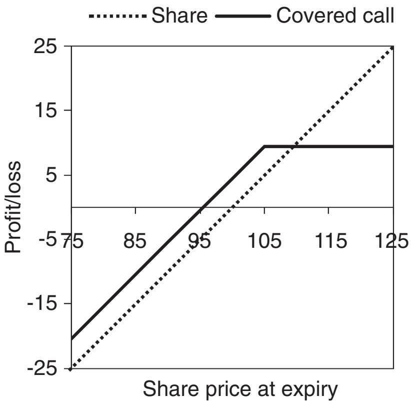

Figure 9.6 Covered call expiry payoff profile

However at share price levels *above* $105 the profit flattens. If the short call is physically settled then above $105 it will be exercised and the investor will have to deliver the share and receive the fixed strike of $105. If the call is cash-settled then any profit the investor earns on the underlying share above $105 will have to be paid out to the buyer of the call option.

One advantage of the covered call strategy is that, because the investor initially collected $4.5 in premium, the share price can fall from $100 to $95.5 before the strategy starts to lose money. Note also that the covered call profile in Figure 9.6 resembles that of a synthetic short put option on the underlying security.

Use of Covered Calls

Portfolio managers often sell calls against their holdings in shares to generate additional income for the fund. This can be particularly valuable in a 'flat' market in which it is difficult to make acceptable returns without taking excessive risks. Covered call writing is far less dangerous than selling 'naked' call options. Normally the strike is set out-of-the-money so that the risk of exercise is limited. If the risk of exercise increases then the fund manager can buy the option back and sell calls struck further out-of the-money.

EQUITY COLLAR

In the first protective put strategy explored above the investor buys a $95 strike put costing $3.5 per share to hedge against losses on a position in the underlying. The main drawback of the strategy is the premium. If the share price rises, it will have to rise by at least $3.5 before the investor breaks even, net of the premium paid.

One alternative is to buy the protective put *and* sell a call on the share, with the same expiry date. The investor will receive premium on the call to offset the cost of the put. This combined strategy is called an **equity collar**.

Suppose the investor buys the $95 strike put costing $3.5, and at the same time sells a $105 strike call. The premium received for the call is $4.5, so the net premium received on the two options combined is $1.

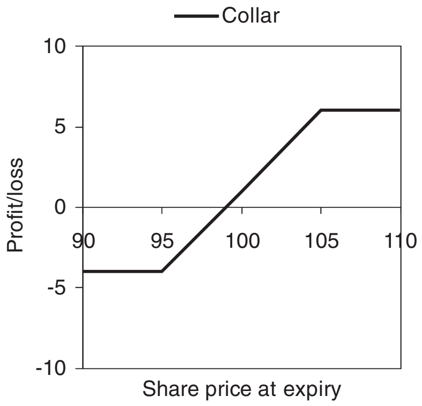

Figure 9.7 Collar strategy expiry payoff profile

Figure 9.7 shows the combined expiry payoff profile – the net profit and loss on the collar for different levels of the underlying at the expiry of the two options. The maximum loss is \$4. This is reached at the strike of the long put. The maximum profit is capped at \$6 per share, which is reached at the \$105 strike of the short call.

ZERO-COST EQUITY COLLAR

A **zero-cost collar** is a hedge strategy which involves buying a put and selling a call against a position in an underlying share with the strikes of the two options set such that the two premiums exactly cancel out.

Suppose that, as before, the investor buys a \$95 strike put against a holding in a share currently worth \$100, but this time also sells a call struck further out-of-the-money at \$107.5. The premium received for the call this time is \$3.5 per share, which exactly offsets the cost of the put option, so the net premium is zero. The payoff profile of the zero-cost collar at expiry is illustrated in Figure 9.8.

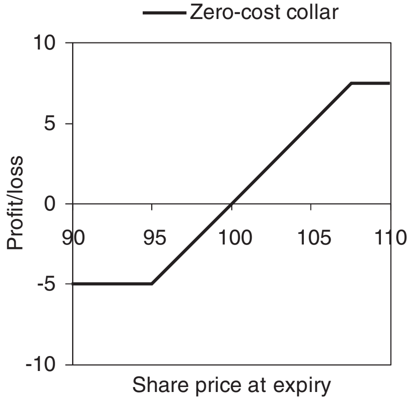

Figure 9.8 Zero-cost collar expiry payoff profile

The net premium on the two options is zero, so the combination strategy payoff profile in Figure 9.8 cuts through the zero profit and loss line at $100. Figure 9.8 also shows that the investor can earn a maximum profit of $7.5 on the underlying share before the short call is exercised. The investor can suffer a maximum loss of $5 on the underlying share before the protection afforded by the $95 strike put comes into effect.

Zero-cost collars are popular with investors for the obvious reason that there is no net premium. However there is a potential **opportunity cost** – if the share price rises above the strike of the short call, the investor's returns are capped, and he or she will underperform rival investors who have not arranged the collar trade.

PROTECTIVE PUT WITH A BARRIER OPTION

The issue for the investor in the case study considered in this chapter is how to hedge the risk of losing money on the share at reasonable cost. There are advantages and disadvantages to all the strategies considered so far:

- **Short Futures.** This does not cost any initial premium but the investor would not benefit if the share price increased. The risk of underperformance in a rising market may be unacceptable.
- **Buy ATM Put.** The premium cost would be relatively expensive and as a result if the share price rose the investor risks underperforming the rest of the market.
- **Buy OTM Put.** This would be cheaper but does not offer as much protection as the ATM put.
- **Construct a Collar.** This saves on premium but at the expense of capping potential gains on the share.

However these are by no means the only choices available. The creation of new generations of 'exotic options' increases the range of possibilities. One such product is the **barrier option** (see Table 9.1 for the different types that are available). A barrier option is a contract whose payoff depends on whether or not the underlying reaches a certain threshold level (the barrier) during a specified period of time over the life of the option.

- A **knock-in** call or put only comes into existence if the underlying price hits the barrier.
- A **knock-out** call or put ceases to exist if the underlying price reaches the barrier.

The barrier level on a knock-in option is sometimes called the **in-strike.** The barrier level on a knock-out option is sometimes called the **out-strike**. Some contracts have both knock-in

Table 9.1 Barrier options

Barrier option type	Characteristic
Up-and-out	Ceases to exist if the price of the underlying rises to hit the barrier level. A knock-out option.
Up-and-in	Comes into existence if the price of the underlying rises to hit the barrier level. A knock-in option.
Down-and-out	Ceases to exist if the price of the underlying falls to hit the barrier level. A knock-out option.
Down-and-in	Comes into existence if the price of the underlying falls to hit the barrier level. A knock-in option.

and knock-out features. Sometimes the buyer receives a rebate on the initial premium paid if a contract is knocked out.

Barrier option terms

Suppose the investor contacts a dealer and finds that a standard three-month put option struck at \$95 would cost \$3.50 per share. Alternatively, the dealer will sell a three-month **up-and-out put** with the following terms:

- Option strike = \$95
- Barrier level = \$105 (the 'out-strike')
- Initial premium payable to the dealer = \$2.30 per share
- Rebate: none.

The barrier option contract is set up such that if the underlying share price reaches \$105 at any time during the next three months the option will cease to exist, and no rebate is payable from the dealer to the investor. However if this does *not* happen then the contract will behave like a standard put option struck at \$95.

Advantages and disadvantages

The advantage of the barrier option is clear: the premium is \$2.30 compared to \$3.50 on a standard put option. If the investor thinks that the share price is unlikely to rise over the next three months then he or she may feel comfortable about incorporating the barrier feature into the contract.

The risk is that if the share price rises during the next three months and hits the barrier, the contract will cease to exist. The investor would lose any protection against a subsequent fall in the share price (and would also have lost the premium).

BEHAVIOUR OF BARRIER OPTIONS

The behaviour of barrier options is interesting. Figure 9.9 shows how the value of the up-and-out put discussed in the last section (solid line) would change in response to an *immediate* change in the spot or cash price of the underlying share. This is not at expiry, but with three months still remaining to expiry and all other factors used to price the option remaining constant. The graph shows the value of a standard or 'vanilla' put option also struck at \$95 for different spot prices of the underlying. Again this is with three months remaining until expiry.

Figure 9.9 shows that, as the spot price of the underlying share rises towards the \$105 barrier, the value of the up-and-out put falls sharply towards zero. This is because it becomes increasingly probable that the option will be knocked out. The vanilla put option also loses value at higher share prices (it moves increasingly out-of-the-money). However it will still continue to exist (there is no knock-out feature) and so the loss in value is more gradual.

Figure 9.9 also shows that at *lower* share prices the vanilla put and the up-and-out put have almost exactly the same value. In such cases the up-and-out put is unlikely to hit the \$105 barrier, and so behaves like a standard put option.

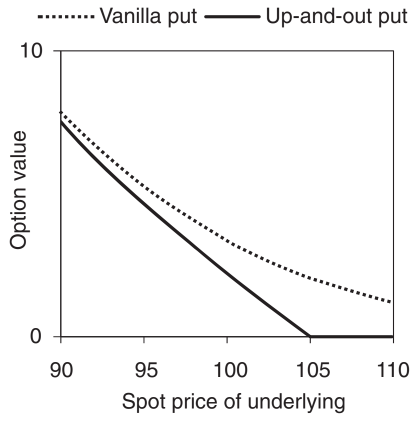

Figure 9.9 Values of barrier and vanilla put options

CHAPTER SUMMARY

An investor who owns a share can short a futures contract or enter into an equity swap to hedge against potential losses. The problem is that potential gains are also eliminated or severely curtailed. As an alternative, the investor can buy a protective put option. This is a type of insurance. If the share price falls, the profit from the put will compensate for the loss in share value. If the share price rises, the put need not be exercised. Unfortunately, buying an option involves paying premium which can reduce investment performance.

Another way to hedge the risk is to construct an equity collar strategy, which can be set up with zero net premium to pay. The strategy consists of buying a put and selling an out-of-the-money call while retaining the long position in the underlying share. A collar produces a maximum loss but a capped profit.

A further way to save premium when hedging with a put option is to buy a put with a barrier feature such that the option is knocked out (ceases to exist) if the share price rises to hit a fixed threshold level. However if the option is knocked out the hedge ceases to exist. The barrier option can be set up such that a rebate is paid to the buyer if it is knocked out, but this will affect the initial premium cost.

10

Exchange-Traded Equity Options

INTRODUCTION

Call and put options on the shares of individual companies can be traded over-the-counter (OTC) with dealers or on major derivatives exchanges such as Eurex, NYSE Liffe, and the Chicago Board Options Exchange (CBOE). On the exchanges the more actively traded contracts can be bought and sold without greatly affecting the market price. In addition, the settlement of contracts is guaranteed by the clearing house associated with the exchange, which effectively eliminates counterparty default risk (see also Chapter 20 which covers clearing).

Some exchanges have introduced so-called **FLEX option** contracts which allow investors to tailor certain terms of a contract. However, most exchange-traded options are standardized. There are a set number of strikes and expiry dates available, and it is not generally possible to trade options on the shares of smaller companies.

By contrast, in the OTC market dealers will sell and buy options on a wide range of underlying shares, as long as they can find a way to manage the risks involved. Also, OTC dealers offer a huge variety of nonstandard contracts known collectively as **exotic options**. Appendix B describes some of the main types of exotic options.

BASIC CONCEPTS

With some exchange-traded options the buyer is not required to pay the full premium at the outset. Instead, the buyer deposits a proportion of the premium as initial margin. However if the option is exercised the full premium has to be paid.

In other cases, such as the options on individual shares traded on NYSE Liffe discussed below, the full premium is payable up-front. However, the *writers* of option contracts are subject to margin procedures. Initial margin is deposited with the clearing house at the outset, and additional margin payments may be required if a position moves into loss. The initial margin depends on the degree of risk involved, calculated according to factors such as the price and volatility of the underlying and the time to expiry of the option contract.

Derivatives exchanges also offer listed option contracts on major **equity indices** such as the S&P 500 in the US, the FT-SE 100 in the UK, the French CAC 40 and the DAX 30 in Germany. Contracts are of two main kinds. Some are options on equity index futures, and exercise results in a long or short futures position. Other contracts are settled in cash against the cash price of the underlying index. If a call is exercised the payout is based on the cash index level less the strike. If a put is exercised the payout is based on the strike less the cash index level.

Options on indices and other baskets of shares can also be purchased directly from dealers in the OTC market.

Covered warrants

The covered warrant is a further alternative to the equity option contracts traded on specialized derivatives exchanges. The main difference is that warrants are normally listed on a stock exchange, and can be bought and sold on the exchange in the same way as shares. This can make them more attractive to retail investors.

Covered Warrants Defined

A covered warrant is a longer-dated option issued by a financial institution based on the shares of another company. It trades as a security that can be bought and sold by investors. The term 'covered' means that the issuer is writing an option and hedges the risks involved, often by trading in the underlying shares.

Warrants are bought by both institutional and retail investors (historically the market in Germany has been particularly active). They can be calls or puts, and written on a single share or on a basket of shares. When exercised some are settled in cash but others are settled through the physical delivery of the underlying shares.

CBOE STOCK OPTIONS

The Chicago Board Options Exchange (CBOE) is the key market for listed options on US stocks. To help explain how these contracts work, Table 10.1 shows the prices of trades in Google stock options on the CBOE taken in mid-December 2009. The Google share price was $592 at the time the data were taken.

Premiums in Table 10.1 are quoted in dollars and cents per share, although the contract size is based on 100 shares. This is the normal lot size on US listed stock options. These contracts are physically delivered, which means that exercising an option results in the delivery of 100 of the underlying shares per contract.

The following bullet points take some examples from the table.

- **December 2009** $**580 Call**. This is in-the-money. It conveys the right to buy shares for $580 each that are currently worth $592. The premium is $14.90. Intrinsic value is $12, so the time value is $2.90.
- **December 2009** $**600 Call**. This is out-of-the-money and the premium of $3.30 is all time value.

Table 10.1 Google stock option prices on the CBOE: underlying share trading at $592

Expiry Date	Strike ($)	Call premium ($)	Put premium ($)
19 December 2009	580	14.90	1.80
19 December 2009	600	3.30	10.90
16 January 2010	580	24.00	10.20
16 January 2010	600	12.70	21.00

Source: Chicago Board Options Exchange

- **January 2010 $600 Call**. This is also out-of-the-money, but it costs more than the December 2009 $600 call. It has more time value, because there is more time for the share price to increase.

The $600 strike put in Table 10.1 is in-the-money because it confers the right to sell Google shares above the current spot price of $592. By contrast, the $580 strike put is out-of-the-money. The January 2010 $580 strike put option is significantly more expensive than the December 2009 $580 strike put option; this is because there is more chance that the share price will fall to low levels over a longer time period.

Expiry payoff profile

Figure 10.1 shows the payoff for a long (bought) position in the $600 strike January call in Table 10.1. The assumption is that the option is purchased at a premium of $12.70 and held to expiry. The break-even point is reached when the underlying share is trading at $612.70 at expiry. At that level the intrinsic value of the call cancels out the initial $12.70 premium paid. (The values in Figure 10.1 are shown on a per share basis.)

Early exercise

The CBOE stock options are American-style, and can generally be exercised on any business day before expiry. In practice, however, it rarely makes sense to exercise a call option early. Only the intrinsic value is earned, and the option is 'killed off' in the process, destroying any time value. Instead, the contract can be sold at the current market premium, which will include the intrinsic value *plus* any remaining time value.

The main exception to this rule occurs when the underlying share has a dividend forthcoming. In this case it can sometimes make sense to exercise a call early to buy the share and secure the dividend payment.

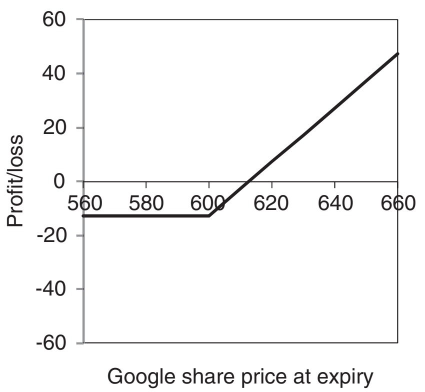

Figure 10.1 Expiry payoff profile for long call on Google

Table 10.2 BP stock option prices on NYSE Liffe: underlying shares trading at 576 pence

Strike (pence)	Call premium (pence)	Put premium (pence)
560	29.38	11.00
580	15.88	20.38
600	8.38	32.88

Source: LIFFE Administration and Management

UK STOCK OPTIONS ON NYSE LIFFE

The contract size for most UK stock options traded on NYSE Liffe is 1000 shares and the option premiums are quoted in UK pence per share.

Table 10.2 shows some sample quotes for stock options on the shares of the British energy company BP PLC. These are the offer or ask prices for contracts posted by dealers placed on the NYSE Liffe electronic dealing system. At the time the quotations were taken the option contracts listed here had about five weeks remaining until expiry. The underlying BP share price at the time was 576 pence (GBP 5.76).

The following bullet points take some examples from Table 10.2:

- **560 Strike Call**. This option is in-the-money. The premium is 29.38 pence per share. Intrinsic value is $576 - 560 = 16$ pence so the time value is 13.38 pence per share.
- **560 Strike Put**. This option is out-of-the-money. The premium is 11 pence per share. Intrinsic value is zero so the premium is all time value.
- **600 Strike Put**. This option is in-the-money. The premium is 32.88 pence per share. Intrinsic value is 24 pence so the time value is 8.88 pence per share.

Table 10.2 only shows a small sample of the strikes available in BP options at the time. Most market participants tend to deal in at-the-money options. As the underlying share price fluctuates, the exchange creates additional strikes so that there are sufficient contracts available likely to appeal to buyers and sellers.

Open Interest

Some traders like to keep track of the **open interest** figures published by the exchange. Open interest shows how many long and short contracts are still outstanding. An excess of put options being traded may indicate that investors and speculators are bearish about the underlying, and are actively buying put options from dealers in anticipation of a sharp fall in its price. An excess of calls may indicate the reverse.

Exercise style

The single stock options on NYSE Liffe are American-style, which means that the holder of an option (a 'long') can exercise the contract on any business day up to and including expiry. If a call with a given strike and expiry date is exercised early, the clearing house will nominate or 'assign' one of the market participants who is short that contract, who will then be obliged to deliver the underlying shares and receive in return the strike price.

Corporate actions and early exercise

The terms of stock options on exchanges are adjusted for certain 'corporate actions', such as rights issues and stock splits and some special dividends.

In a **rights issue** a company sells new shares to existing shareholders. A **stock split** occurs when a share price becomes too high, which may deter some investors. The company issues existing shareholders with a certain number of new shares for each existing share that is owned. The difference compared to a rights issue is that the company is not *selling* the new shares, i.e. it is not raising any additional capital.

However, the terms of stock options are *not* adjusted for regular dividend payments. When a share is declared 'ex-dividend' a purchaser after that date is not entitled to receive the forthcoming dividend payment. The dividend goes to the seller. As a result the market price of the share will fall, and so too will the value of a call on the share. Sometimes this makes it optimal to exercise an in-the-money American call just before the ex-dividend date, in order to receive the share dividend and not suffer from the fall in the value of the option.

CME S&P 500 INDEX OPTIONS

Exchange-traded equity index options make it easy for traders and investors to speculate on, or hedge against, movements in the value of a whole portfolio of shares. Unlike single stock options, these contracts are settled in cash rather than through the physical delivery of shares.

The specification for the CME option on the S&P 500 is set out in Table 10.3. The underlying here is an S&P 500 futures contract. As always, the clearing house acts as an intermediary between buyers and sellers.

The S&P 500 option contracts are American-style and can be exercised on any business day. If the owner of an option exercises a contract, a market participant who is short options is randomly assigned for exercise:

- if it is a call the short will acquire a short position in the futures at the strike price of the option;
- if it is a put the short will acquire a long position in the futures at the strike price of the option.

Option premium

Premiums on the CME S&P 500 options are quoted in **index points**. The dollar value of a premium is the quoted price times the $250 point value.

Table 10.3 CME options on S&P 500 index futures

Underlying:	One S&P 500 stock index futures contract
Index point value:	$250 per full index point
Expiry months:	March, June, September, December, plus serial months
Regular tick size (value):	0.1 index points ($25)

Source: CME Group

Table 10.4 CME options on S&P 500 futures: underlying futures price 1101.20

Strike	Call premium	Put premium
1090	31.20	24.00
1095	28.20	26.00
1100	25.40	28.20
1105	22.70	30.50
1110	20.20	33.00

Source: CME Group

Table 10.4 shows a sample of closing prices for January 2010 expiry S&P 500 index options taken in mid-December 2009. The underlying is the March 2010 S&P 500 futures contract.

On the day the data in Table 10.4 were taken the underlying March 2010 futures contract closed at 1101.20. This information can be used to interpret the option premiums in the table.

- **January 1090 Call**. This is in-the-money relative to the futures price. Intrinsic value is 11.20 points and so time value is $31.20 - 11.20 = 20$ points. In dollar terms the total premium is $7800 per contract.
- **January 1110 Call**. This is out-of-the-money and the 20.20 points premium is all time value.
- **January 1090 Put**. This is out-of-the-money and the 24 points premium is all time value.

Long S&P 500 put: expiry payoff profile

Figure 10.2 shows the expiry payoff profile of a long position in the January put struck at 1090. Profits and losses are shown per contract and in index points. The break-even point is 1066 points, i.e. the strike minus the 24 points premium.

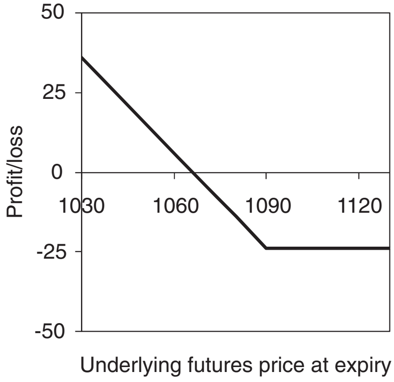

Figure 10.2 Expiry payoff profile of long S&P 500 put struck at 1090

Table 10.5 NYSE Liffe FT-SE 100 index options European-style exercise

Point value:	GBP 10 per full index point
Expiry months:	March, June, September, December plus additional months
Tick size (value):	0.5 index points (GBP 5)
Quotation:	Index points
Expiry:	Third Friday in the contract month

Source: LIFFE Administration and Management

FT-SE 100 INDEX OPTIONS

The contract specification for the Liffe FT-SE 100 index option (European-style exercise) is set out in Table 10.5. Call and put prices are quoted in index points, with a tick size (minimum price movement) of 0.5 index points. The value of a full index point is GBP 10, the same value as for the FT-SE 100 index futures contract.

Quoting premiums in index points makes it easy to carry out break-even calculations. For example, suppose the premium for a 5200 strike FT-SE 100 put is 100 points. This is GBP 1000 per contract. Figure 10.3 shows the expiry payoff profile of a short position in this option. Ignoring transaction costs, the FT-SE 100 index has to be trading below 5100 (the option strike price minus the premium) for the trade to lose money.

When the FT-SE 100 options expire, any open contracts are cash-settled against the value of the underlying index. If contracts expire in-the-money a trader with a long position in an option receives the intrinsic value in cash at GBP 10 per point. Otherwise the contracts expire worthless and the holder has lost the premium.

CHAPTER SUMMARY

The owner of an equity option has the right but not the obligation to buy or to sell an underlying share or basket of shares at a fixed strike price. Exercising an exchange-traded option on an individual share (a stock option) results in the delivery of the share. In the over-the-counter market contracts may be cash-settled.

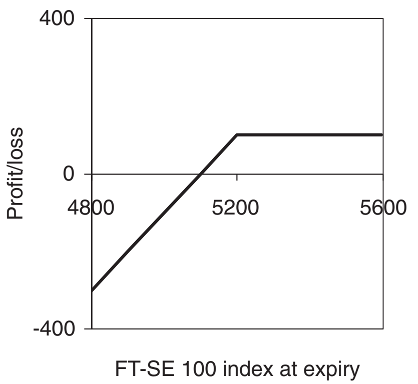

Figure 10.3 Expiry payoff profile of short FT-SE 100 index put

The terms of exchange-traded stock options are not adjusted for ordinary dividends. They *are* adjusted for certain exceptional events such as stock splits and rights issues. American-style contracts can be exercised before expiry, although this kills off any remaining time value. In many cases it is better to retain an in-the-money option or sell it in the market rather than exercise the contract. Exceptions include some deeply in-the-money puts and some calls just before an ex-dividend date.

Exchange-traded options on stock market indices are either settled against the level of the underlying cash index or result in a long or short position in a futures contract on the index. Equity index options offer a diversified exposure to a large number of shares and can provide leverage opportunities – the return on investment can be much higher than that achieved by investing in the actual shares that comprise the index. On the other hand, there is no opportunity to reinvest dividends and the options have a defined life.

The covered warrant is an alternative to exchange-traded equity options. It is a longer-dated option issued by a dealer. It trades in the form of a security which is normally listed on a stock exchange. It can be a call or a put on a single share or a basket of shares or an index. It may be cash-settled or exercise may result in the delivery of the underlying shares. In some countries covered warrants are sold to retail investors.

11

Currency or FX Options

INTRODUCTION

A standard or 'vanilla' **currency** or **FX option** is:

- the right but not the obligation;
- to exchange two currencies at a fixed rate (the strike rate);
- on or by an agreed date in the future (the expiry date).

Contracts are either negotiated directly between two parties in the over-the-counter market, or traded through an organized derivatives exchange. European-style options can only be exercised at expiry, but American-style options can be exercised early if desired. In most cases exercise involves the actual exchange of two currencies, but some FX options are cash-settled. There is an example of a cash-settled contract at the end of this chapter.

Structure of an FX Option

An FX option is a little different to a stock option. This is because the right to sell one currency is also the right to buy the other currency involved in the contract. Suppose that an FX option contract conveys the right but not the obligation to sell EUR 10 million and to receive in return $15 million. In this case:

- the contract is a **euro put** (the right to sell euros);
- it is also at the same time a **dollar call** (the right to buy US dollars);
- the strike rate is EUR/USD 1.5000 i.e. if the option is exercised each euro buys $1.5.

USERS OF CURRENCY OPTIONS

Currency options are widely used by corporations, institutional investors, hedge funds, traders, commercial and investment banks, central banks and other financial institutions. They can be used to:

- limit the risk of losses resulting from adverse movements in currency exchange rates;
- hedge against the foreign exchange risk that results from holding assets such as shares or bonds that are denominated in foreign currencies;
- enhance returns on foreign currency investments;
- speculate on the movements in currency rates.

Chapter 2 explained that a firm due to receive a fixed amount of foreign currency on a future date can cover its exposure to movements in the spot exchange rate by entering into an **outright forward** FX deal. This is an *obligation* to exchange two currencies on a future date at a fixed rate. As such, it has none of the flexibility of a currency option. An FX option need not be exercised if the buyer of the contract can find a better rate of exchange in the spot market. The drawback, of course, is that buying an option costs premium.

Recently, more advanced or 'exotic' currency option contracts have been developed. Partly this is because advanced 'financial engineering' techniques required to create such products and to manage the risks have been developed by specialists.

However, the primary force driving innovation is the need for products that banks and securities firms can use to tailor solutions to client problems. Business and investment have become much more global and the volume of currency transactions has exploded. Currency risk-management problems have become pervasive and more complex. In response, the solutions have become ever more sophisticated.

HEDGING FX EXPOSURES WITH OPTIONS: CASE STUDY

This section introduces a typical hedging case, that of a US company exporting goods to the Eurozone which is paid in euros. The company is due to receive a payment of EUR 10 million in exactly three months' time. The spot rate EUR/USD now is 1.5000. The company could wait three months and sell the euros at the prevailing spot rate at the time. However if the euro weakens against the dollar the firm will receive fewer dollars than expected, and may lose money on the export transaction.

One alternative for the company is to book a three-month forward contract with a bank to sell the EUR 10 million and receive a fixed amount of US dollars. The problem is that the company is obliged to go through with this deal even if it could obtain a better rate on the spot market in three months' time. In addition, if the firm does not receive the euros for some reason it is still obliged to settle the forward FX contract.

An alternative for the company is to buy a three-month euro put (dollar call) on EUR 10 million. This provides the right but not the obligation to sell EUR 10 million in three months at a fixed exchange rate (the strike price) and to receive in return a fixed amount of US dollars. Suppose the firm buys a euro put from a bank struck at 1.5000. The premium is three US cents per euro, or $300 000 million on EUR 10 million.

Performance of the hedge

Table 11.1 analyses the put option hedge and its potential benefits and drawbacks.

For example, if the EUR/USD spot rate in three months is 1.3000 then the company would receive $13 million for the euros at that spot rate. Alternatively, if the firm had bought the 1.5000 strike put as a hedge then the option would be exercised and the company would receive $15 million for the euros. Subtracting the $300 000 premium, the net dollar receipt is $14.7 million. The effective exchange rate achieved would be 1.4700.

$$\text{Effective exchange rate} = \frac{\$14.7\ \text{million}}{\text{EUR 10 million}} = 1.4700$$

$$\textit{Alternatively}: \ \text{Effective exchange rate} = 1.5000 - 0.03 = 1.4700$$

To take one other example, if the EUR/USD spot rate in three months is 1.7000 then the dollars received from selling the euros at that rate would be $17 million. If the corporate had bought the 1.5000 strike euro put the option would expire worthless, and the firm would sell the euros for dollars at the more favourable spot rate. From the $17 million received must be

Table 11.1 Performance of FX hedge strategy

(1) EUR/USD at expiry	(2) $m Unhedged	(3) $m Hedged	(4) Hedged FX rate
1.3000	13	14.7	1.4700
1.4000	14	14.7	1.4700
1.5000	15	14.7	1.4700
1.6000	16	15.7	1.5700
1.7000	17	16.7	1.6700

Column (1) shows a range of possible EUR/USD spot rates in three months' time.
Column (2) shows the dollar amount the US company would receive from selling EUR 10 million at that rate, i.e. if it did not hedge the currency risk.
Column (3) shows the dollar amount the company would receive if it hedged the FX exposure by buying the 1.5000 strike euro put, netting out the initial $300 000 million premium paid.
Column (4) shows for each spot rate in column (1) the effective rate of exchange achieved if the company hedged the FX exposure by buying the euro put option.

subtracted the $300 000 premium, so the net dollar receipt on the hedged position would be $16.7 million. The effective exchange rate achieved is therefore EUR/USD 1.6700.

GRAPH OF HEDGED AND UNHEDGED POSITIONS

Figure 11.1 graphs the results from Table 11.1. The dotted line shows the dollars received at the spot rate, with no hedge in place. The solid line shows the dollars received with the put option hedge in place.

The lines in Figure 11.1 cross when the spot rate is at 1.5000 – 0.03 = 1.4700. At that exchange rate the euros can be sold for $14.7 million on the spot market. The net amount of dollars received if the put was exercised (net of the premium paid) would also be $14.7 million. (Note that this analysis ignores transaction and funding costs.)

The drawback to buying the put, of course, is the cost of the premium, although the company may think it is a reasonable price to pay to manage its currency exposures. If it wished to save premium it could choose an out-of-the-money option. For example, with the same data used to price the 1.5000 strike put, a 1.4000 strike contract would only cost around $27 000.

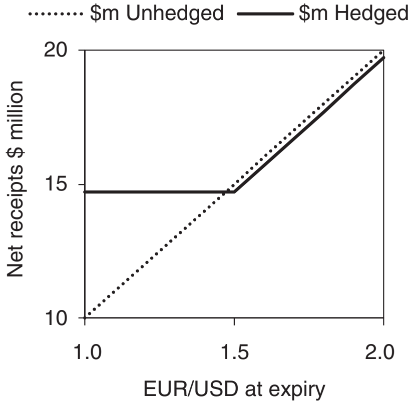

Figure 11.1 Hedged versus unhedged FX exposure

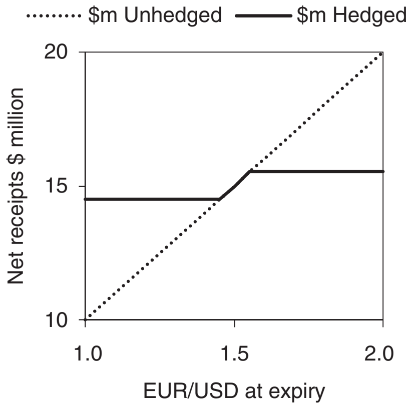

Figure 11.2 Zero-cost collar and unhedged exposure

However, it would only guarantee a minimum receipt of $13.973 million for selling the euros in three months' time, compared to $14.7 million from the 1.5000 strike contract.

HEDGING WITH A ZERO-COST COLLAR

One way for the company in the previous section to eliminate the premium is to construct a **zero-cost collar**. This involves buying a put and selling a call option with the same expiry date, and with the strikes set such that the premiums cancel out.

Suppose this time the company negotiates the following package of options with a dealer. As before, the spot EUR/USD rate is 1.5000. Both options are European-style with three months to expiry and are written on EUR 10 million.

- **Long Put Strike = 1.4500.** The premium payable is $0.0107 per euro or $107 000 in total.
- **Short Call Strike = 1.5520.** The premium received is $0.0107 per euro or $107 000 in total.

Figure 11.2 shows a range of possible spot rates in three months' time and (solid line) the dollars the company will receive if it hedges with the zero-cost collar. It also shows (dotted line) the dollar receipts if it leaves the currency exposure unhedged.

The zero-cost collar will work as follows.

- If the spot rate at expiry is in the range 1.4500 to 1.5520 then neither option will be exercised and the company will sell its euros for dollars at the spot rate.
- If the rate is below 1.4500, the company will exercise the put, sell the euros at the strike of 1.4500 and receive in return $14.5 million.
- If the rate is above 1.5520 the call will be exercised by the dealer that bought the option from the company. The company will have to deliver EUR 10 million and will receive $15.52 million in return.

Zero-cost?

The collar is zero-cost in the sense that there is no initial premium to pay, but not in the sense that the company can never lose out as a result of the deal. If the EUR/USD spot rate in three months is above 1.5520, its gains from a strengthening euro will be capped. However it may be prepared to accept this possibility in return for a hedge that offers reasonable protection with no premium outlay.

REDUCING PREMIUM ON FX HEDGES

Much ingenuity has gone into finding ways of reducing, or at least making more palatable, the premium cost of hedging currency exposures with FX options. One method, covered in the previous section, is to set up a zero-cost collar. However the gains on the spot rate are capped at the strike of the short call.

Barrier option

The first idea was for the company to buy a three-month euro put struck at 1.5000. Unfortunately the premium was \$300 000. An alternative is to use a barrier option (Chapter 9 has more information on these products). The contract could be structured as an **up-and-out put** struck at 1.5000 and with a barrier level set (for example) at 1.5300. If during the life of the contract the spot rate hits 1.5300 then the option ceases to exist.

The company might reason that if the euro strengthens it will become increasingly unlikely that the put option will ever be required (it will simply sell its euros for dollars in the spot market). Therefore it may be content to have the barrier feature built into the option contract in return for a lower premium.

With the same data used to price the vanilla 1.5000 strike put, the incorporation of an 'out' barrier set at 1.5300 would lower the premium to about \$200 000. It could be reduced still further by lowering the barrier or 'out-strike' level. The risk for the company is that the euro strengthens, the option is knocked out, but the euro later weakens again and there is no longer any protection in place. One way to reduce this risk is to structure the contract so that it can only be knocked out if the spot rate hits the barrier during specific periods of time.

Pay-later option

A further possibility that might be attractive to the company is a **pay-later** or contingent premium option. With this type of deal there is no premium to pay unless the option is exercised. If it expires out-of-the-money, that is the end of the story. However, the contract *must* be exercised and the premium paid if it is in-the-money at expiry, even if the intrinsic value received through exercise is less than the cost of the premium.

Instalment option

Alternatively, both parties might agree that the premium can be paid in instalments. This can be combined with a feature that allows the buyer of the option to cancel the contract early without having to pay any further instalments. However, if the contract is held to expiry the total premium paid by instalments is greater than the premium that would have been paid on a standard or vanilla option.

COMPOUND OPTIONS

One of the exotic options developed in recent years is the **compound option**. This is an option on an option. The contracts that are most likely to appeal to a firm or investor hedging currency exposures are of two types.

- **Call on a Call**. This is the right to purchase a call option at a later date at a fixed cost.
- **Call on a Put**. This is the right to purchase a put option at a later date at a fixed cost.

A common application occurs when a company is participating in a tender and realizes that it may need to buy a call or a put option to hedge its currency exposures if it is successful. However, the company is not yet sure that it will win the tender and does not wish to pay the full premium for an option that may never be required.

Hedging application

Suppose this time that a US company is pitching for some new business in the Eurozone, but the deal is not yet signed. It is asked by its potential client to quote a fixed price in euros. The company will find out if its bid is successful in one month's time. If it is, it will be paid by the client in three months' time.

Suppose also that at the current spot rate EUR/USD 1.5000 the company could afford to quote a tender price of EUR 10 million to its potential client for the new business, which it believes will be competitive. That would translate into $15 million at the current spot rate, which would cover its costs and achieve a reasonable profit margin. However, if it quotes EUR 10 million and the euro *weakens* appreciably over the next three months it would lose money on the business deal. The dollar proceeds from selling the euros would fail to cover its costs.

The company could consider the following hedging strategies.

1. **Forward FX Deal.** Arrange to sell EUR 10 million in three months' time at a fixed exchange rate. The problem is that the company does not know if it is going to win the tender, and it would be obliged to go through with the forward deal whatever happened.
2. **Buy a Euro Put.** Using the values from previous sections of this chapter, a three-month put on EUR 10 million struck at 1.5000 would cost $300 000 in premium. However this is a lot of money for an option that it will not need if the company fails to win the tender.
3. **Buy a Compound Option.** A suitable contract would be a call on a euro put – the right but not the obligation to buy a euro put option. If the company wins the tender it can exercise the compound option and would then own a standard euro put option.

Compound option structure

As an example, the company could buy a call on a put with a **first strike** of $0.03 per euro or $300 000 on EUR 10 million. The **second strike** is $1.5000 per euro or $15 million on EUR 10 million. The initial premium for the compound option is $90 000. The **first expiry date** is in one month. The **second expiry date** is in three months.

The stages in the life of the contract are as follows.

- **Now**. The company agrees the terms and pays an initial premium of \$90 000 for the compound option.
- **In One Month**. The company must decide whether or not to exercise the compound option and buy the underlying put. If it does it will then have to pay the first strike price (a further premium) i.e. \$300 000.
- **In Three Months**. If it has bought the put the company must in turn decide whether to exercise that option. If it does so it will have to deliver EUR 10 million and will receive \$15 million at the second strike.

The decision on whether or not to exercise the compound option on the first expiry date in one month really depends on the value of the underlying put at that stage. If the put is worth more than its purchase cost at the first strike – in this case \$300 000 – then the compound option should be exercised. Otherwise it should not.

Of course there is an obvious drawback to this strategy. If the company wins the tender and exercises the compound option it will end up paying a total of \$90 000 + \$300 000 = \$390 000 for the put option it requires. It could have purchased that option in the first instance for \$300 000. That is the price of flexibility.

EXCHANGE-TRADED CURRENCY OPTIONS

Most currency options are traded over-the-counter (OTC) by dealers, although contracts are also traded on exchanges such as NYSE Liffe, CME and the Philadelphia Stock Exchange (now part of NASDAQ OMX group).

Market Size

According to the Bank for International Settlements, the notional amount outstanding on exchange-traded FX options at end-June 2009 was \$103.9 billion. BIS statistics are available on www.bis.org

CME currency options

CME offers FX futures and options contracts on major currency pairs as well as currencies that are now growing in importance, such as the Chinese renminbi and the Brazilian real. It offers European-style as well as American-style option contracts. All trades on the exchange are guaranteed by the central counterparty CME Clearing.

CME currency options are **options on futures**. This means that if a holder of an American-style call exercises the contract early it becomes a long futures position at the strike price. If the holder of a put exercises it becomes a short position in the futures. In-the-money FX options are automatically exercised at expiry. Most FX futures contracts on CME involve the physical exchange of the two currencies at expiry, though some are cash-settled.

PHLX world currency options

The Philadelphia exchange (PHLX) offers **dollar-settled** European-style contracts in a range of major currencies against the US dollar, including the British pound, the Japanese yen and the euro. The premiums are paid in dollars and the contracts are cash-settled in dollars rather than through the physical delivery of the foreign currency.

For example, suppose the spot rate between the euro and the dollar EUR/USD is 1.5000 and a trader buys an October call on PHLX struck at 150 (which means 1.5000 dollars per euro). The premium is three US cents per euro. The contract size is EUR 10,000 so the total premium payable is as follows.

$$\text{Premium} = \$0.03 \times 10\,000 = \$300$$

Suppose that when the option expires the exchange rate EUR/USD is 1.5500. The trader can exercise the call or sell it in the market and is paid its intrinsic value in US dollars. In this example this is as follows:

$$\text{Intrinsic value} = (1.5500 - 1.5000) \times 10\,000 = \$500$$

The net profit to the trader is therefore \$500 minus the premium of \$300, which amounts to \$200 on the contract. All sums are paid in cash in US dollars and there is no physical transfer of euros involved.

CHAPTER SUMMARY

Purchasing a currency or FX option provides the right but not the obligation to exchange two currencies at a fixed rate. The right to buy one currency (such as the euro) is also the right to sell the counter-currency (such as the dollar). Unlike OTC deals, exchange-traded options are generally standardized, although exchanges have introduced contracts that allow for some flexibility in the strikes, expiry dates and quotation methods. Some FX options are settled in cash rather than through the physical exchange of the two currencies.

FX options can be used to hedge currency exposures. Because they need not be exercised, they can protect against adverse movements in an exchange rate whilst permitting some degree of benefit if the rate moves in a favourable direction. The drawback is the cost of the premium. One way to reduce or eliminate the premium cost for an FX option hedge is to construct a collar strategy. This can be set up with zero net premium to pay. The snag is that gains from currency movements are capped at a certain level. Another way to reduce premium when buying options to hedge currency exposures is to incorporate a barrier feature into the contract.

An option contract can also be set up such that the premium is paid in instalments. A company tendering for a business deal that includes currency risk can buy a compound option. If it exercises the compound option, the company will own a standard call or put option which it can then use to hedge its currency risk on the deal.

12

Interest Rate Options

INTRODUCTION

Chapters 3 to 6 discussed forward rate agreements (FRAs), interest rate futures, bond futures and interest rate swaps. These are used by banks, traders, corporations and investors to manage exposures to (or speculate on) changes in interest rates. However the potential gains on these products are balanced by the potential losses.

An interest rate option has a different profile. The expected payout to the buyer (ignoring the premium) is *positive*, since the contract need not be exercised in unfavourable circumstances. This flexibility has a price, the option premium. The premium restores the balance between the buyer and the writer of the option contract.

The products discussed in this chapter are:

- over-the-counter and exchange-traded options on short-term interest rates;
- interest rate caps, floors and collars;
- swaptions (options to buy or to sell interest rate swaps);
- bond options (options to buy or to sell longer-dated debt securities or futures on such securities).

The chapter explores how these products are quoted in the market, and looks at practical applications using a number of short case studies. Chapter 14 has a section on the valuation issues posed by interest rate options.

OTC INTEREST RATE OPTIONS

Since the 1960s central banks and governments around the world have gradually relaxed or abolished controls on currency exchange rates. As a result, the short-term interest rate has become their main weapon against inflation, and is also sometimes used as a means of strengthening or weakening the national currency. This has led, amongst other factors, to increased volatility in interest rates and the need for sophisticated tools to manage interest rate risks. Interest rate options offer a flexible means of achieving this purpose.

FRA Hedge

A corporate borrower concerned about rising interest rates can hedge by buying a forward rate agreement (see Chapter 3). However there is a drawback. If interest rates *fall* the borrower has to pay a settlement sum to the seller of the FRA. Of course this will be offset by lower interest costs on the borrower's underlying debt, but it will nevertheless suffer an **opportunity loss**. Net of the settlement payment made on the FRA, its effective borrowing cost will be higher than if it did not have the FRA hedge in place.

An alternative strategy for a corporate borrower is to hedge interest rate exposures by buying over-the-counter (OTC) or exchange-traded interest rate options. An **OTC interest rate call** is essentially an option to buy an FRA.

- If at the expiry of the option the LIBOR rate for the period covered by the contract is set above the contract rate (the strike rate) the corporate will exercise the call.
- It will then receive a cash settlement sum from the writer of the option. The payment is calculated in the same way as it would be for a standard FRA contract.
- However if LIBOR is equal to or lower than the strike rate then the option contract will expire worthless and no further payment is due to the writer.

Since the buyer of the option has the privilege of exercising the contract in favourable circumstances, or otherwise allowing it to expire worthless, the buyer will have to pay an up-front premium to the writer of the contract.

OTC Interest Rate Put

An investor concerned about falling interest rates can buy an OTC interest rate put option. This is effectively the right but not the obligation to sell an FRA to the option counterparty (normally a bank). The put will be exercised at expiry if the LIBOR rate for the period covered by the contract is set *below* the option strike rate. The investor then holds a sold FRA contract which is cash-settled – that is, a cash settlement sum is received from the counterparty. If at expiry the LIBOR rate is equal to or above the strike rate, the put is left to expire worthless and the investor has lost only the initial premium paid.

OTC INTEREST RATE OPTION CASE STUDY

Interest rate call options are used as components of interest rate caps (these are discussed later in this chapter), and as a result are sometimes known as **caplets**.

This section explores a case in which a company buys a European caplet (a call on an FRA) from a dealer. The contract specification is set out in Table 12.1. The underlying FRA is identical to that explored in Chapter 3, which also discusses FRA settlement and how LIBOR is used in the settlement process. As in that chapter, the complexities of the day-counting method used to calculate LIBOR interest payments are ignored in this example.

The caplet gives the company the right but not the obligation to buy an FRA with a notional principal of $100 million at a fixed rate of 5% p.a. The caplet expires in six months. At that point the company has to decide whether or not to exercise the option. It if does exercise, the

Table 12.1 Caplet contract specification

Notional principal:	$100 million
Deal type:	Company buys an interest rate call option (a caplet)
Strike rate:	5% p.a.
FRA contract period:	A future six-month period starting in six months' time
Reference rate:	Six-month US dollar LIBOR
Expiry date:	In six months' time
Exercise style:	European, i.e. the caplet can only be exercised at expiry
Premium:	0.25% p.a.

company will acquire a long (bought) position in an FRA. The time period covered by the underlying FRA begins when the caplet expires, and ends six months later.

The caplet premium in Table 12.1 is expressed in terms of a per annum interest rate, though the underlying FRA covers a six-month time period. The premium cost of the caplet in dollar terms is as follows.

$$\text{Caplet premium} = \$100 \text{ million} \times \frac{0.25\%}{2} = \$125\,000$$

Caplet exercise and settlement

The premium is paid by the company to the dealer, and then nothing more is done until six months later. At that point the dollar LIBOR rate for the contract period will be set by the British Bankers' Association (BBA).

Suppose that the LIBOR rate is actually set at 6% p.a. In that case the company will exercise the caplet and will buy an FRA at a contractual rate of 5% p.a. In practice, this simply means that it will receive a settlement sum from the dealer who sold the caplet. This is calculated in the normal way for an FRA. In this example it is based on the difference between 6% p.a. and 5% p.a. applied to the notional principal for a six-month time period.

$$\text{Settlement sum} = \$100 \text{ million} \times \frac{6\% - 5\%}{2} = \$500\,000$$

To be rather more accurate, this is actually the settlement payment that is due 12 months after the option purchase date, because interest rates are conventionally quoted on the basis that interest payments are made in arrears. As discussed in Chapter 3, it is standard practice to settle an FRA just after the LIBOR rate for the period is announced and not in arrears, and to discount or reduce the settlement sum to reflect this fact. In this example the settlement would take place when the caplet expires, i.e. six months after its purchase date.

If the LIBOR rate is fixed *at or below* 5% p.a. when the caplet expires in six months' time then the company will simply let the contract expire. No settlement sum has to be paid by either party. However the dealer that sold the caplet has earned, and the company that bought the contract has lost, the initial \$125 000 premium.

HEDGING A LOAN WITH A CAPLET

Why would the company in the case explored in the last section buy the caplet? One possible reason is that it has borrowed money and pays a variable rate of interest on the loan. Suppose the company has a \$100 million loan and the rate of interest on the loan is reset every six months at US dollar LIBOR + 1%. This means that the interest rate payable for each six-month period will be whatever the BBA LIBOR rate is set at for that period, plus a fixed margin of 1% p.a. Suppose also that the next date for resetting the interest rate is in six months.

Clearly, if dollar interest rates rise the company will face higher borrowing costs, which may affect its overall profitability. It could buy an FRA to hedge the risk. If rates increased it would receive a cash settlement sum. However, as shown in Chapter 3, the bad news is that the payments on an FRA are equal and opposite. In other words, if interest rates *fell* the company would have to make a settlement payment to the seller of the FRA.

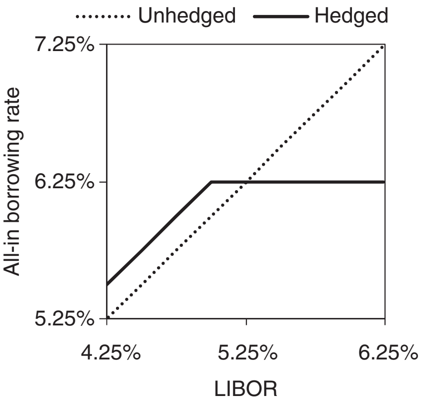

Figure 12.1 Unhedged exposure versus caplet hedge

Results of the hedge

If the company buys the caplet struck at 5% p.a. it can protect itself against rising interest rates in the future, while still being able to benefit if rates fall. To see why this is so it is helpful to consider a number of scenarios. Here are three possible levels at which LIBOR may be fixed for the period covered by the caplet.

- **LIBOR = 4.25% p.a**. The company will not exercise the FRA. Its all-in cost of borrowing is 4.25% p.a. plus the 1% p.a. margin over LIBOR on its loan plus the 0.25% p.a. caplet premium. The total is 5.5% p.a.
- **LIBOR = 5.25% p.a**. The company will exercise the FRA and receive a settlement sum of 0.25% p.a. Its all-in borrowing cost is $5.25\% + 1\% + 0.25\% - 0.25\% = 6.25\%$ p.a.
- **LIBOR = 6.25% p.a**. The company will exercise the FRA and receive a settlement sum of 1.25% p.a. Its all-in borrowing cost is $6.25\% + 1\% + 0.25\% - 1.25\% = 6.25\%$ p.a.

The company's borrowing cost for the six-month period covered by the caplet is *capped* at 6.25% p.a. However, if rates fall it is not locked into a high rate, because it does not have to exercise the caplet.

Figure 12.1 illustrates this fact. It shows the company's all-in borrowing cost if it buys the caplet (solid line). It also shows (dotted line) its cost of borrowing if it leaves the exposure unhedged. The two lines cross when the LIBOR rate for the period is set at 5.25% p.a.

Summary of Caplet Features

A caplet is the right but not the obligation to buy an FRA at a fixed rate, called the strike rate. It does not have to be exercised. The buyer of a caplet is paid a settlement sum if the interest rate for the period covered by the contract is set above the strike rate. Otherwise the caplet simply expires and no settlement payment has to be made. The bad news is that the buyer of a caplet has to pay an initial premium to the seller of the contract. At expiry this is a 'sunk cost', i.e. it cannot be recovered.

INTEREST RATE CAP

The caplet explored in the last section limits the company's borrowing rate only for the six-month future time period covered by the contract. The company may decide that it also wishes to protect itself against increases in interest rates for the *subsequent* payment periods on its loan. To do this it could buy a series or **strip** of caplets.

The first caplet, as before, would cover its interest payment on the loan for the time period 6v12 (for six months starting in six months); the second caplet would cover the time period 12v18 (for six months starting in 12 months); and so on. A strip of caplets with the strikes all set at the same level is called an **interest rate cap**.

Buying an Interest Rate Cap

As the name suggests, a cap strategy is used to cap or limit a borrower's effective funding rate for a series of future interest payment periods. If for any one of the periods the actual LIBOR rate is set above the strike, then the buyer of the cap is compensated in cash by the writer of the contract. The cap premium is simply the sum of the premiums of the constituent caplets. It is either paid in a lump sum at the outset, or in instalments, often on dates that match the interest payments made on the borrower's underlying loan.

Pricing caplets and caps

A caplet is priced in relation to the **forward** or expected interest rate for the future time period it covers. If the market is expecting increases in LIBOR rates over the years ahead, and the forward rates are higher than cash market rates, this can mean that the premium cost of a cap (a series of caplets) with a strike set around current interest rate levels is prohibitively expensive.

The writer of the cap would have to take into account the likelihood of having to make a series of settlement payments to the buyer over the life of the contract. In other words, the expected payout from the cap is high, and this has to be factored into the premium that is charged. Often in this type of case the cap strike is set *above* current interest rate levels to save on premium.

INTEREST RATE COLLAR

A borrower may choose to combine the purchase of a cap with the sale of an **interest rate floor** with a strike set at a lower rate. It would normally agree this as a package deal with an option dealer. The combined strategy is called an **interest rate collar**.

If the LIBOR rate for a payment period is set *above* the cap strike, the borrower receives a settlement sum from the dealer. However, if the LIBOR rate is set *below* the strike of the floor the borrower has to make a settlement payment to the dealer. The effect for the borrower is to establish a maximum and a minimum funding rate. If the strikes of the cap and floor are set appropriately then the premiums cancel out and there is zero net premium to pay on the deal. This structure is called a **zero-cost collar**.

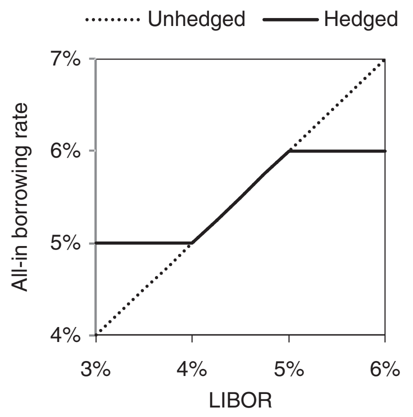

Figure 12.2 Interest rate hedge with a zero cost collar

Zero-cost collar case study

Suppose that a company has borrowed $100 million on a floating rate basis. Interest payments are made every six months in arrears, and the payment for a period will be set at the start of each period at LIBOR + 1% p.a.

The company agrees a zero-cost collar strategy with a dealer. In this deal:

- the company buys a cap struck at 5% per annum;
- the company writes a floor struck at 4% per annum;
- the notional principal in both cases is $100 million.

Payouts on the collar are made every six months to match the payments on the company's underlying loan.

Figure 12.2 shows the result of the zero-cost collar strategy. Because of the hedge, the company's minimum cost of borrowing for any one of the six-monthly periods covered by the collar is 5% p.a. This is the 4% p.a. floor level plus the 1% margin over LIBOR it pays on its underlying loan. The company's maximum cost of borrowing for any period is 6% p.a. This is the 5% cap level plus the 1% margin over LIBOR on its loan.

If the LIBOR rate for a six-monthly period is set *between* the floor and the cap level, then neither the floor nor the cap level comes into operation. For example, if LIBOR is set at 4.5% p.a. the company's all-in borrowing cost for that period is simply the LIBOR rate plus the 1% p.a. margin on its loan, which comes to 5.5% p.a.

INTEREST RATE SWAP AND SWAPTION

Another alternative for the borrower in the case explored in previous sections is to enter into an **interest rate swap**, in which it receives a floating rate linked to LIBOR and pays in return a fixed rate of interest. The notional on the swap would be set at $100 million and the payments would be made every six months in arrears to match its underlying loan. Chapter 6 describes interest rate swaps and their use in such hedging applications.

By using a swap the company can fix its borrowing costs. The advantage is that if interest rates rise sharply the company will not suffer as a result. It has known borrowing costs for the lifetime of the swap, and it can plan its business activities accordingly. The drawback is that it cannot benefit from any *decline* in interest rates. Compare this with the zero-cost collar, where the company can benefit from falling interest rates as long as they do not fall below the strike of the floor.

Payer swaption

As a further alternative, the company could buy a European-style **payer swaption**. This confers the right but not the obligation to enter into an interest rate swap at the expiry of the swaption. If the company exercises the swaption it will enter into a swap deal in which it pays a fixed rate of interest and receives LIBOR. The notional principal, payment dates and interest calculations on the underlying swap would all be specified in the contract.

The swaption provides flexibility. The company has the choice over whether or not to exercise and to enter into the swap specified in the contract. In addition, if at expiry the fixed rates on interest rate swaps in the market are higher than the fixed rate agreed in the contract, a payer swaption would be in-the-money and could be closed out at a profit.

Zero-cost Collar versus Swaption

There are two important differences between using a zero-cost collar and a swaption to hedge interest rate risks. Firstly, there is premium to pay on a swaption. Secondly, the swaption can only be exercised once. If exercised, the hedger acquires a position in an interest rate swap. The collar consists of a *series* of interest rate options covering different time periods, each of which individually may or may not be exercised depending on how the actual LIBOR rate for the period compares with the strikes of the cap and of the floor.

SUMMARY OF INTEREST RATE HEDGING STRATEGIES

A borrower paying a variable rate of interest on a loan has a lot of choice if it is considering hedging its interest rate exposure. It will have to make its decision based on its attitude to risk, its views on the likely direction of interest rates and its willingness or otherwise to pay premium. Here are a few possibilities:

- **Do Nothing**. In which case its borrowing costs will increase if interest rates rise.
- **Buy an FRA**. This will fix its effective borrowing rate for one time period only.
- **Pay Fixed on a Swap**. This will fix its effective borrowing rate for a series of future time periods. If interest rates fall it cannot benefit.
- **Buy a Caplet**. This will cap its effective borrowing rate for one future time period only. However, it incurs a premium cost.
- **Construct a Zero-cost Collar**. This establishes a minimum and a maximum borrowing rate for a series of future time periods. There is no premium. However, the company can no longer benefit if interest rates fall below the strike of the floor.
- **Buy a Payer Swaption**. This is the right to enter into a swap paying a fixed rate and receiving a floating rate. If interest rates rise, the borrower can exercise the swaption and fix its effective borrowing rate for a series of future time periods. If rates fall the swaption need not be exercised. However, it incurs a premium cost.

EURODOLLAR OPTIONS

Borrowers and investors can also use exchange-traded interest rate options to manage their interest rate risks.

Chapter 5 has details of the Eurodollar futures contracts traded on Chicago Mercantile Exchange (CME). They are widely used by financial institutions to manage their exposures to changes in short-term interest rates.

As explained in Chapter 5, a Eurodollar futures contract is based on a three-month \$1 million notional deposit starting on a specified future date. The price quotation is made in terms of 100 minus the annualized interest rate for that time period. The notional principal is not exchanged. Instead, there are a series of margin payments based on the changing price of the contract in the market. A movement of 0.01 in the futures price is equivalent to a change of one basis point (0.01% p.a.) in the interest rate for the time period covered by the contract.

CME also offers an **option contract** on the Eurodollar futures. It works as follows:

- **Long Call**. If a long call is exercised it results in a long (bought) position in a Eurodollar futures contract, which benefits from falling interest rates.
- **Long Put**. If a long put is exercised it results in a short (sold) position in a Eurodollar futures contract, which benefits from rising interest rates.
- **Exercise Style**. The option is American-style. If an option is exercised early a trader who is short contracts is randomly assigned a futures position. If it is a call, this results in a short position in the futures for the assigned trader. A put results in a long position. At expiry in-the-money options are automatically exercised.

Trading Eurodollar options

Suppose that a trader buys one December Eurodollar put option contract struck at 98.00. The underlying December futures on CME is also trading at 98.00. The option premium is 10 basis points. Each full basis point is worth \$25, so the dollar premium is calculated as follows.

$$\text{Premium cost} = 10 \text{ basis points} \times \$25 = \$250$$

The put is **at-the money** since it confers the right to sell a futures at 98.00 when it is also trading at this level on the exchange. Therefore the option has zero intrinsic value and the premium cost is purely time value. The underlying futures price is based on the *expected* interest rate for the three-month period starting in December.

$$\text{Expected interest rate} = 100 - 98.00 = 2\% \text{ p.a.}$$

Profits and losses on Eurodollar options

When the underlying futures contract expires in December its final settlement or closing price is based on the *actual* LIBOR rate set for the three-month time period covered by the contract. Suppose in this case the LIBOR rate for that period is set at 3% p.a. Then the December futures will close at a final settlement price of 97.00.

$$\text{Final settlement price} = 100 - 3.00 = 97.00$$

The trader owns a put that provides the right to sell a Eurodollar futures at the strike price of 98.00. This is profitable, because the futures has closed 100 basis points *below* that level at

97.00. The net profit is as follows.

$$\text{Intrinsic value} = 100 \text{ basis points} \times \$25 = \$2500$$
$$\text{Net profit (intrinsic value less premium)} = \$2500 - \$250 = \$2250$$

Suppose, on the other hand, that the December futures closes at expiry at (say) 99.00, based on a LIBOR rate set for the period at 1% p.a. Then the put option will simply not be exercised. For the buyer of the contract, the worst that can happen is that the option expires out-of-the-money and the initial premium has been lost.

EURO AND STERLING INTEREST RATE OPTIONS

Similar interest rate option contracts are traded in Europe. The three-month Euribor futures traded on NYSE Liffe (through its electronic network) is based on a EUR 1 million deposit starting in March, June, September or December plus other months. A Euribor option contract is the right to buy or to sell one Euribor futures.

Euribor® (Euro Interbank Offered Rate) is a key reference rate for short-term lending in euros. It is sponsored by the Brussels-based European Banking Federation (FBE) and the Financial Markets Association (ACI).

A one basis point move in the market value of a Euribor option is worth EUR 25, although the price can change in half-point intervals. Exercise can take place on any business day and results in a position in the futures with the expiry month associated with that option. For example, the exercise of a long December call results in a long position in the December futures. Exercising a long March put results in a short position in the March futures.

NYSE Liffe also offers an option on three-month sterling interest rate futures. This time the underlying futures is based on a notional GBP 500 000 deposit, so a one point move in the price quotation is worth GBP 12.50.

Option Premium Margining

The buyer of a Euribor or sterling interest rate option on NYSE Liffe does not pay the full premium at the outset. Instead the buyer deposits initial margin, the option position is marked-to-market on a daily basis, and variation margin payments are made or received depending on the changing market value of the option.

BOND OPTIONS

Bond options are classified as interest rate options because bond prices are critically affected by changes in market interest rates. Many bond options in the OTC market are European-style contracts. A European bond option confers the right but not the obligation to buy or sell a bond on a specified date at an agreed price, the strike price. By contrast, exchange-traded contracts are options on bond futures and can be exercised on any business day up to and including expiry. Here are some of the most important applications of OTC bond options.

Hedging

The owner of a bond is concerned about a temporary rise in interest rates (which would reduce the value of the bond), but would prefer not to sell. One possibility is to short bond futures, so that losses on the bond are compensated by gains on the futures. However profits on the bond would also be offset by losses on the futures. An alternative is to buy a put option. If the bond price falls, the put will generate offsetting profits. If the bond price rises, the put can be left to expire. However, the option costs premium.

Zero-cost collar

Institutional investors dislike paying premium because it affects the performance of the fund. The owner of a bond who is concerned about a fall in price can buy an out-of-the-money put and sell an out-of-the-money call. If the strikes are set appropriately then the premiums cancel out and there is zero net premium to pay. The owner is protected if the bond price falls below the strike of the long put. Unfortunately gains on the bond are capped if the bond price rises above the strike of the written call.

Covered call writing

An investor who owns a bond can generate additional income by writing an out-of-the-money call on the asset. The premium received will enhance investment performance. If the bond price rises above the strike and the call is exercised, the investor is covered, since he or she can deliver the bond.

Leveraged position taking

A trader who thinks that interest rates are set to fall can buy an at- or out-of-the-money call on a fixed rate bond. This is much cheaper than buying the underlying bond. If rates do fall the value of the bond will rise. The value of the call option will also rise, and it can then be sold back in the market at a profit. The return on capital is greater than would have been achieved if the actual bond had been purchased. This is the 'leverage' effect of options.

EXCHANGE-TRADED BOND OPTIONS

Chapter 4 examines bond futures contracts traded on the Chicago Board of Trade and other exchanges.

Table 12.2 sets out the specification of the 30-year **US Treasury bond option** contract traded on the CBOT. The underlying here is a futures contract, so that if a long call is exercised

Table 12.2 CBOT 30-year US Treasury bond option

Unit of trading:	One 30-year US Treasury bond futures of a specified delivery month
Contract months:	March, June, September, December plus others
Exercise style:	American, i.e. the buyer of an option can exercise on any business day. Options that are in-the-money are automatically exercised at expiry.

Source: CME Group

the holder acquires a long position in a US Treasury bond futures contract. If a long put is exercised the holder acquires a short position in a US Treasury bond futures contract. A long or short futures position is settled in the way described in Chapter 4.

Euro-bund options (OGBL)

The German government bond (Euro-bund) option traded on Eurex, the combined Swiss-German exchange, is a key contract in the Eurozone. The underlying is one Euro-bund futures contract. A call option is the right to buy a specific bund futures contract at the strike price. A put is the right to sell a specific futures at the strike price.

The bund futures is based on EUR 100 000 par value of a notional German government bond. The futures price is quoted per EUR 100 par value. The tick size (minimum price movement) is 0.01 per EUR 100 par value, i.e. 0.01%. The value of each tick on the contract size is therefore EUR 10.

$$\text{Tick value} = \text{EUR } 100\,000 \times 0.01\% = \text{EUR } 10$$

The premiums on the bund option contracts are quoted in the same way. Suppose that a trader buys a 120 strike Euro-bund call option contract. This is the right but not the obligation to buy a specific bund futures contract at a price level of 120.00. Suppose further that the trader has to pay a premium for the call option of EUR 0.50 per EUR 100 par value, i.e. 50 ticks (each tick is 0.01). The premium payable in cash terms is calculated as follows.

$$\text{Premium} = 50 \text{ ticks} \times \text{EUR } 10 = \text{EUR } 500$$

If the contract is exercised then the trader acquires a long position in the underlying Euro-bund futures at a price level of EUR 120 per EUR 100 par value.

Break-even Level

In this example the underlying futures would have to be worth 120.50 for the trader to break even by exercising the call option. In that case the trader would make a profit on exercise of 50 ticks or EUR 500, because the call provides the right to buy the futures at 120.00. This recovers the initial EUR 500 premium paid. If the futures is worth *more* than 120.50 then the profit from exercising the option exceeds the premium paid. In practice, though, brokerage and funding costs also have to be taken into account.

Long gilt option

This contract is traded on NYSE Liffe. It is an American-style option and can be exercised on any business day. Exercise results in a long or short position in a specific gilt futures contract, i.e. a futures on British government bonds. The underlying futures contract is based on GBP 100 000 par value of a notional 6% p.a. coupon gilt.

One feature of gilt options that is different to the NYSE Liffe stock options explored in Chapter 10 is that the premium is not paid in full at the outset. Instead, like a futures contract, the buyer deposits initial margin, followed by a series of variation margin payments and receipts depending on the changing value of the option contract. However if a trader who owns gilt option contracts decides to exercise, the original premium cost must be paid to the clearing house, which credits the account of a trader who is short the relevant contracts.

CHAPTER SUMMARY

An interest rate option is a contract whose value depends on future interest rates. An OTC interest rate option is a call or a put on a forward rate agreement (FRA). An OTC interest rate call is also known as a caplet. If at expiry the actual interest rate for the period covered by the contract is set above the strike, the holder of the call is compensated in cash. Otherwise the contract expires worthless. The snag is that the caplet costs premium.

An interest rate cap is a series or strip of caplets with the same strike. The premium is the sum of the premiums of the constituent caplets. A borrower concerned about rising interest rates can buy a cap and also sell a floor to offset the premium cost. This is called a collar and establishes a maximum and a minimum rate of interest.

A European swaption is the right but not the obligation to enter into an interest rate swap on a future date either as the payer or as the receiver of the fixed rate. It can only be exercised once, at expiry.

An OTC bond option conveys the right but not the obligation to buy or to sell a bond at a fixed strike price. Exchange-traded bond option contracts on the CBOT, Eurex and NYSE Liffe are options on bond futures. If an option is exercised it results in a long or short position in a bond futures contract. Bond options can be used to take speculative trading positions, to hedge against changes in interest rates and bond prices, and to generate additional premium income for a fund invested in fixed income securities.

13

Option Valuation Concepts (1)

INTRODUCTION

As discussed in Chapter 8, the value of an option has two components:

- **Intrinsic Value**. This measures any money that can be released by exercising an option. It is either zero or positive. An option that has positive intrinsic value is said to be in-the-money.
- **Time Value**. This measures the value of an option over-and-above any intrinsic value it has.

Even if an unexpired option has no intrinsic value it will still have some time value. Time value reflects the chance that the option *may* move in-the-money before expiry. Generally speaking, this chance is greater:

- the longer the time remaining to expiry;
- the greater the volatility of the underlying asset (the more that returns on the asset fluctuate).

Taken together these factors – time to expiry and volatility – represent opportunities for the buyer of an option and risks for the writer. Time value is also affected by the level of interest rates. For example, the buyer of a call can deposit the strike price until the contract is exercised. Higher interest rates provide a greater income advantage in buying the call compared to buying the underlying asset in the first instance.

Calculating intrinsic value is easy, but time value is another matter. The problem is that, unlike (say) a Treasury bill, the eventual payout from an option is not fixed. It depends critically on what happens to the price of the underlying asset over the life of the contract. Option valuation requires a way of modelling the possible payouts resulting from buying or selling an option and the probabilities that these will occur.

Black-Scholes model

The standard model for pricing European stock options is commonly known as the **Black-Scholes** model. (Appendix A shows how it can be set up on an Excel spreadsheet.) It is beyond the scope of an introductory text such as this to explain the mathematics behind the model. The main aims here are, firstly, to provide an intuitive insight into the hedging argument that is critical to the Black-Scholes pricing methodology, and then to focus on the inputs to the model and how changing these inputs affects the valuation it produces.

In the financial markets relatively few people work through all the mathematics underlying option pricing, especially the techniques used to price the more complex exotic options developed in recent years. Nevertheless many people in finance rely on pricing models in their day-to-day work and need to develop a reasonable understanding of the inputs and the outputs, the key assumptions and the practical limitations.

THE CONCEPT OF A RISKLESS HEDGE

At first glance it might seem that the obvious solution to pricing an option is to forecast what is likely to happen to the price of the underlying asset in the future.

The problem with this approach is that it is based on **subjective probability**. Someone who is convinced that the price of a given share is certain to rise would be prepared to pay a high premium for an at-the-money call option on that share. Meantime, someone else who forecast a sharp fall in the share price would think that the call option was virtually worthless. There would be no 'fair price' for the option on which everyone could agree.

Risk Neutrality

The Black-Scholes model does not use subjective probabilities. It is based on the idea that a trader can write an option and eliminate the risks involved in doing so. This is the concept of a **riskless hedge**. In effect, the model says that the value of an option is determined by the cost of managing the hedge.

Tackling the Black-Scholes model directly requires a knowledge of calculus. Fortunately, there is a much easier way of understanding how it works, and that is to create something called a **binomial model** (or binomial tree). As more and more 'steps' are added to a binomial tree, the value it calculates for a stock option converges on the result produced by Black-Scholes. The next section shows how a very simple binomial model can be constructed, using a riskless hedge strategy, and also how this methodology can be used to price an option.

A SIMPLE OPTION PRICING MODEL

This section and the following section construct a **one-step binomial model** and then use the model to price a European call option. The call is written on an underlying share which is currently trading at \$100. To keep things very simple, it is assumed that the share pays no dividends and that market interest rates are zero.

The share is also rather unusual in that over one time period it can only move up to \$125 or down to \$75. This is illustrated in Figure 13.1. In the Figure 'Time 0' is now, and 'Time 1' is one time period in the future. It does not matter in this simple example what one time period actually is: it could be an hour, or a day, or a week.

Suppose that at time zero (now) a trader writes an **at-the-money call** on the share, i.e. a call option with a strike of \$100. The contract is written on 100 shares. The call expires at time

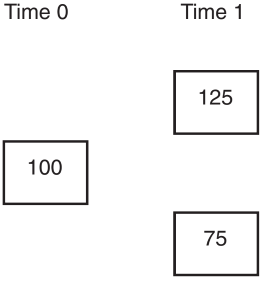

Figure 13.1 One-step share binomial tree

one. It is cash-settled, which means that at expiry the trader will pay any intrinsic value that the option has over to the buyer of the option contract.

The potential payouts from the option *at expiry* are easy to work out. There are in fact only two possibilities.

- **Share Price** = $**125**. The strike of the call is $100 so the intrinsic value of the option is $25 per share, or $2500 on 100 shares. The writer of the call has to pay this over to the buyer of the contract.
- **Share Price** = $**75**. In this case the call expires out-of-the-money and has zero intrinsic value. The writer of the call pays out nothing to the buyer of the contract.

Constructing a riskless hedge

How much premium should the trader charge for writing the call at time zero? The answer depends on what it would cost to hedge the risk. The trader can fully hedge the call by doing two things at time zero:

1. **Buy 50 Underlying Shares.** The purchase cost is 50 × $100 = $5000.
2. **Borrow** $**3750.** This loan is used to help fund the $5000 purchase cost of the 50 shares. The rest of the purchase cost ($1250) is met by the premium earned by selling the call option. The borrowing will be repaid at time period one. In this example it is assumed that there will be no interest to pay on the loan.

The **option delta** in this case (also known as the hedge ratio) is 0.5 or one-half. It means that if the trader sells a call on a certain number of shares (100 in the example) then he or she has to buy half that number of shares to hedge the risk. Trading in the underlying in this way to hedge the risk on an option is called a **delta hedge**.

Purpose of the hedge

The reason for the delta hedge is simply this. If at expiry the share price is $125 the trader will have to pay out $25 per share on the written call, or $2500 on the contract size of 100 shares. However in this scenario the payout will be *fully covered* by the value of the 50 shares, less the money that has to be repaid on the loan.

$$\text{Value of shares} - \text{Loan repayment} = \$125 \times 50 \text{ shares} - \$3750 = \$2500$$

On the other hand if the share price is $75 at expiry the trader will not have to pay out anything on the written call. This is matched by the value of the 50 shares purchased in the hedge less the loan repayment amount.

$$\text{Value of shares} - \text{Loan repayment} = \$75 \times 50 \text{ shares} - \$3750 = \$0$$

How the Riskless Hedge Works

In other words, whether the share price rises or falls, at the expiry of the option (at time one) the writer of the option is fully covered. The payout made on the option is exactly matched by the value of the shares purchased in the delta hedge, less the cost of repaying the initial loan. Note that this technique only works if we can establish the delta value (the hedge ratio). It is critical to the whole methodology.

OPTION FAIR VALUE

The fair value the trader should charge for the call at the outset (at time zero) is simply the total cost of buying the 50 shares in the delta hedge at time zero less the amount borrowed at that stage.

$$\text{Option fair value on 100 shares} = \$5000 - \$3750 = \$1250$$
$$\text{Option fair value per share} = \$12.50$$

In other words, by charging $1250 for the option contract (at $12.50 per share) and by borrowing the remaining $3750, the trader can afford to buy the 50 shares that are needed for the delta hedge.

What this establishes is a **fair value** for the option, in the sense that the trader can sell the call for $12.50 per share, cover the risks through the delta hedge, and break-even on the whole set of transactions. If the trader can sell the call for *more* than the fair value and hedge the risks then he or she can lock-in an arbitrage profit. In theory, a ‘free lunch’ of this kind should not happen, and so the option should trade around its fair value.

Appendix A at the end of this chapter explains how the 0.5 delta value (the hedge ratio) was calculated in this example, and sets out a simplified formula for calculating the option value. However this material is not essential and the rest of the book can be followed if it is skipped. The key learning points are these.

- The standard approach to option pricing is based on a riskless hedging methodology.
- The option delta value is essential to constructing the hedge and therefore to the option valuation.

EXTENDING THE BINOMIAL MODEL

Of course the binomial tree developed in the last sections is highly simplistic. Firstly, it assumes that the share price can only move up to $125 and down to $75 over one time period. In reality, the price will tend to move up or down by much smaller steps, and then to take a series of further steps.

Secondly, the price levels $125 and $75 used above were simply invented for the purposes of illustration. It would be helpful to build a model that takes into account the **volatility** of the underlying share. Intuitively, the more volatile the share, the more its price will tend to deviate over time from the current spot level.

A Multi-step Model

These problems can be tackled by building a **multi-step binomial tree**. Essentially what this does is to break the time to the expiry of the option into a number of discrete time steps. Starting from its current spot level, the share price can move up or down. Then it can take a further step up, or a further step down. The volatility assumption that is ‘fed’ into the model determines how far the share price moves from its starting point over a given time period.

Dynamic hedging

The multi-step binomial tree approach prices an option by using what is known as a **dynamic hedge**. This contrasts with the static hedge described in a previous section, in which the option delta value was 0.5 and a fixed quantity of shares (50) was purchased to manage the risk on the short option position.

With a dynamic hedge if the share price keeps rising, and the written call moves more and more in-the-money, then the option delta value also rises. In practical terms this means that the trader who sold the call has to buy *additional* shares in the underlying to match the higher level of risk on the option position. On the other hand, if the share price falls then the trader has to sell some of the existing shares in the hedge portfolio to match the lower level of risk on the option position.

Eventually, if the call moves deeply in-the-money, the delta approaches a limit of one. In other words, if the trader has written a call on 100 shares which is deeply in-the-money, then he or she has to own 100 shares in the delta hedge portfolio. A deeply in-the-money option behaves rather like a position in the underlying and so has to be hedged with a completely offsetting position in the underlying stock.

COST OF DYNAMIC HEDGING

There is a potential cost to dynamic hedging:

- if the underlying share price rises, the writer of the call will have to *buy more* shares in the underlying (at a higher price) to readjust the hedge;
- however if the share price then falls back again to where it was before, the writer of the call will have to *sell* the additional shares (at a lower price) to rebalance the hedge;
- the result of this activity is to realize a trading loss (buy the shares at a high price, sell them at a low price).

Traders sometimes think of the initial premium charged for writing an option as a ‘bag of money’ that is used to manage the dynamic hedge. If the share price turns out to be as volatile as forecast when the option was priced, then the option writer will be able to rebalance the delta hedge over time using the money initially collected in premium. On the other hand, if the share price fluctuates *more* than was forecast, the writer will lose money overall. The cost of rebalancing the hedge will exceed the initial premium that was collected.

The Significance of Volatility

The moral is that the key to option pricing is understanding **volatility**. If the underlying asset turns out to be *more* volatile than forecast when the option was sold, then the writer will lose money by writing the option and managing the risk using the delta hedging method. But if the underlying price turns out to be relatively *stable* over the life of the option, the writer will be able to rebalance the hedge from time to time, and at expiry will still have some of the premium earned by selling the option left over as a profit.

THE BLACK-SCHOLES OPTION PRICING MODEL

The Black-Scholes model can be thought of as a binomial tree with an infinite number of steps. To put it another way, the more steps that are added to a binomial model, the more the option value it calculates converges on the Black-Scholes result. The same fundamental ideas are used in both cases, as follows:

- **Riskless Hedge**. It is assumed that it is possible to manage an option position by constructing a riskless hedge, which involves trading in the underlying asset.
- **Delta**. The value of delta (the hedge ratio) tells a trader how to construct the hedge.
- **Dynamic Hedging**. The delta of an unexpired option changes in response to changes in the price of the underlying asset, so that the hedge has to be readjusted from time to time.

Chapter 15 describes another measure used by traders called option **gamma**. This measures the extent to which the delta value changes. It is a sensitivity number. It tells a trader how unstable or otherwise the delta hedge is likely to be, and how often it may have to be readjusted. Gamma is a very useful tool, particularly when writing shorter-dated at-the-money options, which often tend to be the most difficult contracts to hedge.

Inputs to Black-Scholes

The Black-Scholes model (adapted for a share that pays dividends) needs only five inputs to price a European-style option. The fair value of an option – the theoretical price that should be paid for the contract – is the expected payout at expiry discounted back to the day the option is purchased and the premium paid. The model inputs and outputs are pictured in Figure 13.2.

Model inputs: spot price and strike price

The first two inputs are the **spot or cash price** of the underlying asset and the **strike price** of the option. These establish whether or not the option has any intrinsic value. They also help to determine how likely or otherwise it is that the option will be exercised.

For example, if an unexpired call has a strike of \$100 and the spot share price is \$100, then the option has zero intrinsic value. However there is a good chance – something like an even chance – that the share price will be above \$100 at expiry and the option will expire in-the-money. However, if the spot price is \$100 and the strike of a call is \$200 it is far less likely that the call will ever be exercised. Assuming they share the same underlying and expiry date, the value of an out-of-the-money option is generally less than that of an at-the-money option.

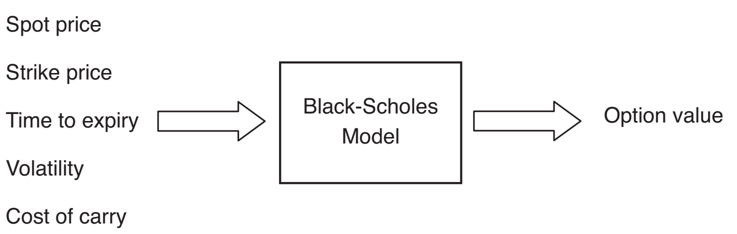

Figure 13.2 Black-Scholes option pricing model

Model inputs: time to expiry and cost of carry

Chapter 8 discussed the importance of the **time to expiry** in valuing an option. There is a greater chance that the price of a share will change substantially over a year than during a day. Other things being equal, therefore, a longer-dated option tends to be more valuable because it provides more profit opportunities for the holder.

Input number five to the model – the **cost of carry** – is also quite straightforward. It is the rate of interest that applies to the expiry of the option, less any dividends that will be paid out on the underlying over that time period. The binomial example showed that the writer of a call option can hedge the risk by buying shares in the underlying, partially funded by a loan. Therefore the cost of borrowing, less any dividends that are earned on the share while it is held in the hedge portfolio, affects the premium the writer has to charge for the option.

Model input: volatility

Finally, the model requires an estimate of the **volatility** of the underlying share over the life of the option. The measurement of volatility is discussed in the next section, but the reason why the model requires this input is clear. Other things being equal, an option on a highly volatile share is more expensive than one on a share that trades in a narrow range. The chance of an extreme price movement is greater, and the option has a higher expected payout.

Why Doesn't the Effect of Volatility Cancel Out?

If a share price is highly volatile this increases the chance that it will rise sharply, which increases the potential profits for the buyer of a call. But it also makes it more likely that the share price will *fall*. Don't the two effects cancel out? The answer is 'no' because the situation is not symmetrical. If the share price rises to high levels the buyer of the call can exercise and make a substantial profit. However if the share price falls the buyer is not forced to exercise and can only lose the initial premium paid for the contract.

HISTORICAL VOLATILITY

Of the five inputs to the model, only the volatility assumption is really problematical. The spot price is available on the stock market. Nowadays it is likely to be broadcast widely on electronic news services such as Reuters or Bloomberg. The strike of an option is a matter of agreement between the various parties, as is the time to expiry. It is not too difficult to forecast the dividend income on a share if the option expires in a few weeks or months (although with longer-dated contracts forecasting dividends becomes increasingly speculative).

The problem is that the model requires an assumption about the volatility of the underlying asset over the life of the option. This will determine the expected payout on the contract. Unfortunately the future volatility of an asset cannot be directly observed, so it has to be estimated or forecast in some way.

A useful starting point is to look at the past price behaviour of the underlying share and calculate its **historical volatility**. This can be used as the basis for a forecast of the future.

Historical Volatility Defined

This is measured statistically, as the **standard deviation** of the percentage returns (price changes plus dividends) on the share over a historical time period. The more extreme the fluctuations in the share price over the period, the greater the volatility value that will be calculated. Appendix A has an example.

Standard deviation

Standard deviation is a measure of dispersion around an average value, and is widely used in many applications, not just in finance and business. As an example, Figure 13.3 is a histogram showing the distribution of heights in a sample (it was based on 1000 women in the UK). On the horizontal axis heights have been grouped into ranges. The vertical axis shows the proportion of the sample that falls into each range.

If narrower and narrower ranges are taken, the graph would increasingly begin to resemble the famous **bell curve,** also known as the normal or Gaussian distribution. This is illustrated in Figure 13.4. The shape of the curve means that most of the sample is grouped around the **mean** or average value – i.e. most people are around the average height, and far fewer are at the extremes.

A bell curve has certain defining characteristics:

- It has a single peak at the exact centre. The mean or average is also the value that appears most frequently in the distribution of values. Half the area of the curve is above the mean and half is below.
- The curve is symmetrical and falls off smoothly in either direction. For practical applications this is a little unrealistic. It is unlikely that any members of the human population are over (say) 10 metres tall.
- In fact there is not just one but a whole family of bell curves. The shape of a curve is defined by the mean value and the standard deviation, which measures the extent to which the values deviate from the mean.

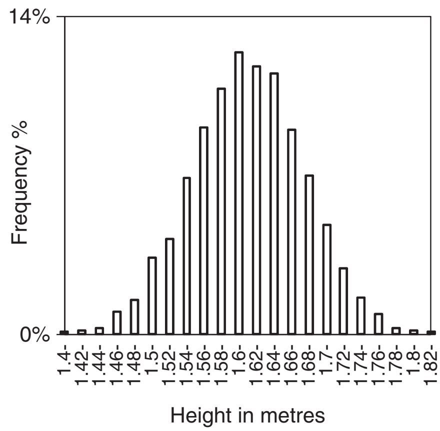

Figure 13.3 Histogram based on a sample of heights

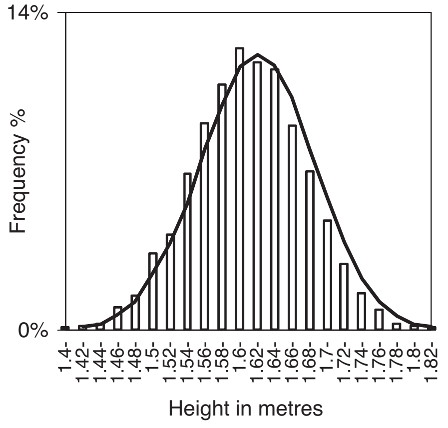

Figure 13.4 Histogram with bell curve plotted

MEASURING AND USING HISTORICAL VOLATILITY

Measuring the standard deviation of the returns on a share is similar to calculating the standard deviation for a sample of heights. As described in more detail in Appendix A, there are three stages to the procedure.

- **Step 1**. Collect a sample of prices of the underlying share over some historical period. For example, this could be based on the daily closing prices on the stock exchange over one month or over three months.
- **Step 2**. Calculate the daily percentage price changes and then the average of these values. This is the mean or the middle point in the bell curve.
- **Step 3**. Calculate the standard deviation (volatility) by measuring the extent to which the actual percentage price changes in the sample deviate from the average value.

Percentages values are used in this calculation, to ensure that the standard deviation values of shares trading at different prices levels are directly comparable.

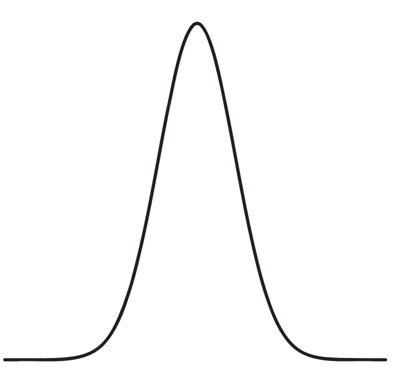

Figure 13.5 Distribution with lower standard deviation

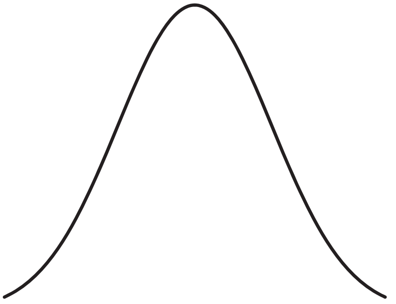

Figure 13.6 Distribution with higher standard deviation

Application to Black-Scholes

Graphically, a small standard deviation produces a bell curve that is tall and bunched around the mean (Figure 13.5). A larger standard deviation value will generate a curve that is much more spread out (Figure 13.6).

Applied to Black-Scholes, what this means is that (other inputs being equal) an option on a share whose returns are assumed to follow the distribution in Figure 13.6 will be more valuable than one whose performance is assumed to follow the graph in Figure 13.5.

The greater the volatility of a share, the greater the chance of an extreme price movement. This increases the expected payout to the option buyer, and hence the initial premium charged by the writer of the contract.

CHAPTER SUMMARY

European-style stock options can be priced using a binomial model or the Black-Scholes model. In both cases pricing is based on the idea that a riskless hedge can be assembled by trading in the underlying asset. The hedge ratio (as measured by the option delta) is not constant and so the hedge has to be adjusted in response to changes in the spot price of the underlying.

Black-Scholes requires five inputs: the spot price of the underlying; the strike; time to expiry; the volatility of the underlying; and the net carry cost – the cost of borrowing money less any income earned on the underlying. The most problematical input is volatility. This cannot be directly observed and must be estimated. Historical volatility is based on past movements in the price of the underlying and may not reflect the future.

Chapter 14 continues exploring option valuation concepts. It defines implied volatility and explains how it is derived and applied. It considers how the values of call and puts are affected by changes in the spot price of the underlying; and also how Black-Scholes is adapted to price index, currency and interest rate options.

14
Option Valuation Concepts (2)

INTRODUCTION

Chapter 13 explained the basics of option pricing. It discussed the binomial pricing approach and the industry-standard Black-Scholes model for valuing European stock options. It described the inputs to the model and the importance of volatility. This chapter introduces the concept of implied volatility and explains its applications. It uses Black-Scholes to show how the values of calls and puts are affected by changes in the spot price of the underlying. Finally, the chapter explores issues relating to pricing index, currency and interest rate options.

PROBLEMS WITH HISTORICAL VOLATILITY

The advantage of using historical volatility to price an option is that (normally) the sample data are readily available and the calculation is quite straightforward. In fact all the necessary functions required to work out the mean and the standard deviation for a set of data are included in spreadsheet packages such as Excel. However, there are serious practical and theoretical problems when using historical volatility to price options.

- **The Sample Data**. What is the correct historical time period on which to base the sample of price data? Perhaps it is best to use data from the last few months, since this is likely to be most representative of the current behaviour of the underlying. However, this risks not capturing the more extreme price movements that happen infrequently. This could underestimate volatility. Equally, including data that are old and stale is a mistake; the nature of the underlying asset may have altered fundamentally in the meantime.
- **The Past and the Future**. An even more serious problem is that historical volatility is by its very nature based on what happened to the underlying in the past. What really matters when pricing an option is how volatile the underlying is going to be *over the life* of the contract. This is what will determine the expected payout to the buyer and the expected loss to the seller.

Unfortunately, there is no way of directly observing how volatile an asset will be in the future. It is necessary to make a forecast. To some extent this is likely to be based on what has happened in the past – on the historical volatility – but it is also necessary to incorporate reasonable expectations on the future events that are likely to affect the level of volatility.

For example, the price of an underlying share may have suffered a period of extreme turbulence in recent months, perhaps driven by factors that are specific to the company such as a boardroom crisis; or perhaps the result of general instability in the stock market. An option trader might conclude that things are now likely to settle down a little, and that the level of volatility over the next few months will decline. In a different case a trader may foresee events that are likely to *increase* the volatility of a share – such as takeover speculation.

IMPLIED VOLATILITY

When options are freely traded on exchanges and in the over-the-counter market, it is quite easy to obtain data on the premiums at which they are currently being dealt. This can be used to calculate **implied volatility**.

> **Implied Volatility Defined**
>
> Implied volatility is the volatility assumption built into the actual dollar price of an option. It is obtained by 'operating the pricing model backwards'. In other words, rather than using a volatility assumption to determine the dollar value of an option, the dollar price at which it is trading in the market is used to determine the volatility assumption that would generate such a price.

The calculation of implied volatility is illustrated in Figure 14.1. In the calculation, all the other inputs to the pricing model – spot price, strike, time, carry cost – are kept constant. The volatility assumption is adjusted by trial-and-error until the model produces an option value equal to the actual market dollar price of the option.

Applications of implied volatility

Implied volatility is used by dealers, risk managers and buyers of options who are attempting to decide which contracts represent good value and those that are overpriced. There are a wide range of practical applications.

- **Establishing Market Consensus**. Options on stocks such as Microsoft and on indices such as the S&P 500 are actively traded. From the general level of premiums being charged for such options on the market, it is possible to extract the market's consensus expectation on what the volatility of the underlying asset is likely to be over the time to expiry of the contracts. Assuming it is a fair and efficient market, with many participants, it can be argued that implied volatility provides an unbiased estimate of future volatility. It builds in the market's consensus expectations on all the future events that are likely to affect the future price behaviour of the underlying asset, based on currently available information.
- **Establishing Relative Value**. Buyers and sellers can normally agree on the other inputs to valuing an option, so the key decision when setting the price of a contract concerns the volatility assumption. A trader who is considering buying an option can contact a dealer, ask for a price, and insert that value into the pricing model. This will reveal the volatility assumption used by the dealer to derive the option premium. If the trader thinks the

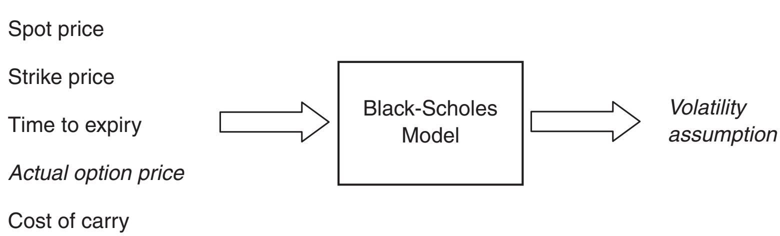

Figure 14.1 Extracting implied volatility

share will be *more volatile* than the dealer predicts, then the trader should consider buying the option. Its expected payout is likely to be greater than the premium charged by the dealer.

BLACK-SCHOLES MODEL ASSUMPTIONS

The Black-Scholes model makes some simplifying assumptions about the world that have a tendency to break down in extreme market conditions. These include the following.

Normal distribution

That model assumes that the returns on the underlying asset follow a normal distribution, the famous bell curve. Many analysts believe there is a pronounced skew or ‘negative tail’ in the actual returns on shares, meaning that there is a bigger chance of significant losses than is built into the shape of the bell curve. Other assets such as currencies may exhibit positive *and* negative tails.

Continuous random walk

The model assumes that the returns on the underlying follow a continuous random walk, i.e. they follow a path in which the last price movement bears no relationship to the next price movement and in which prices are not subject to sudden ‘jumps’. This may be a realistic assumption in a normal market but not in a market crash.

Dynamic hedging

The model assumes that it is possible to delta hedge option positions by buying and selling the underlying without transaction costs and without liquidity constraints. In the real world, option traders do face transaction costs and liquidity problems, and will not be able to readjust their delta hedges on a continuous basis.

Fixed volatility

The model assumes that the underlying has a known level of volatility which stays constant over the life of the option. In a market crash, however, experience suggests that panic sets in and volatility can increase sharply.

Option traders can compensate for the limitations of the model by adjusting the implied volatility at which they sell options. For example, if the underlying is not very liquid and is hard to trade it will be difficult to manage the risks on a short option position. To compensate, the trader can increase the price of the option such that the implied volatility is greater than the actual historical volatility of the underlying. Otherwise, traders can use more complex models which relax the key Black-Scholes assumptions, e.g. by allowing shifts in volatility.

VALUE OF A CALL OPTION

This section explores the relationship between the spot or cash price of the underlying and the value of a European call as calculated by Black-Scholes.

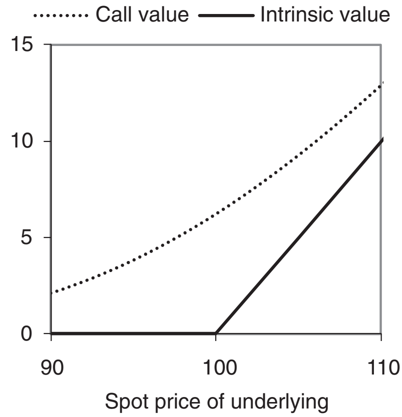

Figure 14.2 Relationship between call value and underlying price

Figure 14.2 shows (dotted line) the value of a \$100 strike European call for different spot prices of the underlying share. The other inputs to the pricing model have been kept constant, including volatility and time to expiry. The graph also shows (solid line) the intrinsic value of the call. The difference between the solid line and the dotted line in the graph represents time value.

Figure 14.2 shows that when the call is deeply out-of-the-money then it has zero intrinsic value and also very little time value. The underlying has to rise above the strike for the call to expire in-the-money. The probability of that happening is relatively small. Nevertheless, the probability is not zero, and has to be paid for through time value.

Figure 14.2 also shows that as the share price increases *towards* the strike (other inputs to the model remaining constant) the time value of the option also rises. The chance of the option expiring in-the-money is increasing. Time value peaks around the at-the-money level, when the price of the underlying and the strike are equal.

Time value for an in-the-money option

Figure 14.2 also shows that as the call moves *into* the money, the total option value continues to increase (it acquires more and more intrinsic value). However the time value component steadily declines. This is because buying a deeply in-the-money call is rather like buying the underlying.

Time value for an in-the-money option primarily represents the additional amount an investor is prepared to pay, over and above the intrinsic value, for the privilege of owning an option with limited downside risk. Unlike holding the actual asset, the loss is limited to the premium. The more in-the-money the option is, however, the smaller the time value – there is less chance that the ‘disaster insurance’ that the option provides will actually be required.

VALUE OF A PUT OPTION

Next, Figure 14.3 shows the total value and the intrinsic value of a long European put option with similar terms to the call explored above. The strike price is \$100.

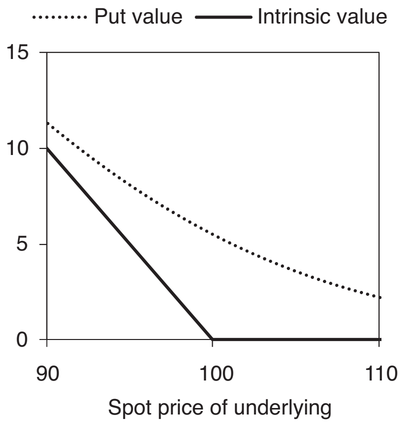

Figure 14.3 Relationship between put value and underlying price

Figure 14.3 shows that the value of the put increases (decreases) as the share price falls (rises). Again intrinsic value is either zero or positive, but this time it is positive when the current share price is *below* the strike (when the put is in-the-money).

Time value is highest when the put is around the at-the-money level. As it moves further into the money, the long put increasingly resembles a short position in the share. It is highly likely that it will be exercised.

Probability of Exercise

Although it is a simplification, market practitioners sometimes think of option value in terms of probability of exercise. The probability of an out-of-the-money option being exercised is low. The probability of an at-the-money option being exercised is around 50%. If an option is very deeply in-the-money then the probability of it being exercised and being turned into a position in the underlying asset approaches 100%.

EQUITY INDEX AND CURRENCY OPTIONS

There is a variant of the Black-Scholes pricing model that is adapted for pricing European options on stock market indices such as the S&P 500. (See also Appendix A.) This version of the model requires five inputs:

- the **spot** or cash price of the underlying index;
- the **strike** or exercise price of the option;
- the **time to expiry** of the option;
- the **volatility** of the underlying index;
- the **cost of carry** – the interest rate less the dividend yield or return on the index.

This version can be further adapted to price European currency or foreign exchange (FX) options, and in this guise is commonly known as the **Garman-Kohlhagen** model. For example, a sterling call (dollar put) is simply the right to buy pounds (the underlying) and to pay in return a fixed price in US dollars. Therefore in the model:

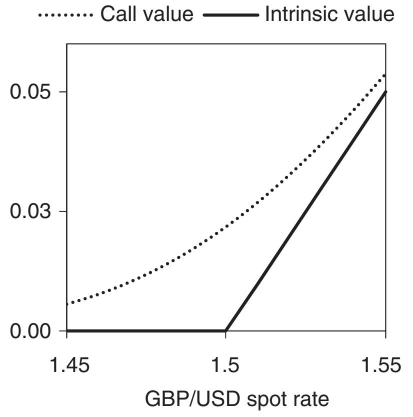

Figure 14.4 Value of sterling call for different spot GBP/USD rates

- the spot price of the underlying becomes the GBP/USD spot rate;
- the volatility is the volatility of the spot rate;
- the cost of carry becomes the difference between the dollar and the sterling interest rate.

Value of an FX call option

Figure 14.4 shows the value of a three-month sterling call (dollar put) for a range of different GBP/USD spot rates. All the other inputs have been kept constant. The strike of the option is 1.5, i.e. it confers the right to buy one pound sterling and to pay in return $1.50.

Figure 14.4 shows the relationship between the spot rate and the call value.

- **Spot = 1.50**. If the spot rate is 1.50 (the same as the strike) then the call is at-the-money. It has no intrinsic value. However it has quite a lot of time value because there are three months remaining until expiry.
- **Spot = 1.55**. The call is in-the-money. Its intrinsic value is five cents per pound. It is worth slightly more than five cents because of the additional time value.
- **Spot = 1.45**. The call is out-of-the-money. It has zero intrinsic value and the time value is relatively low. The chance of profitable exercise is relatively low.

PRICING INTEREST RATE OPTIONS

The Black-Scholes model was originally developed to price stock options. The last section showed how it is modified to price European-style equity index and currency options. Since a bond is just another type of financial asset, it might seem reasonable to extend the methodology still further to price options on bonds.

Bond option pricing example

However consider the following case. The underlying asset is a one-year US Treasury bond trading at $98 in the cash market. It pays no interest, but when it matures in one year the government will repay the face value of $100. (This is called a **zero-coupon bond.**) The task is to value a one-year European call on the bond struck at \$101. An analysis of past changes in the spot price of the bond suggests that the historical volatility is 5% p.a.

The value of the call is quite clearly zero, since it confers the right to buy an asset for \$101 in one year that can only ever be worth \$100 at that point. Yet, with the above inputs (in particular a 5% volatility assumption), the Black-Scholes model will calculate a positive value.

What has gone wrong here? The model assumes that over a period of time there is a chance that the price of an asset will stray from its initial spot price. Generally speaking, the longer the time to expiry, the greater the volatility of the asset, the more that is likely to happen. This is a reasonable assumption in the case of shares, whose values can theoretically rise to any level. The problem with a bond (especially a Treasury bond) is that its market value tends not to deviate very far from its face or par value, the redemption amount paid by the issuer of the bond at maturity. Also, it *does* have a maximum value, the sum of all the future cash flows it pays.

The Pull-to-Par Effect

The price of a bond tends to 'pull' towards its par value as maturity approaches. This is known as the **pull-to-par** effect. No one will pay more than \$100 for a bond that redeems at \$100 very soon. As it approaches maturity, therefore, the volatility of the bond price tends to decline. The value of the bond at maturity is fixed, and as it nears maturity there is less and less uncertainty about the price at which it should trade.

Black model

The mistake was to price the option using a volatility assumption based on the historical behaviour of the spot price. Since it is a European option the call can only be exercised at expiry, in one year's time, when the bond matures. The volatility of the bond price at that point is actually *zero* because its maturity value is *fixed* at \$100.

This way of thinking forms the basis for using the **Black model**, developed in 1976, to price bond options. It prices bond options in relation to the **forward price** of the bond at the expiry of the option. The volatility used is that of the forward price, to correct for the fact that volatility declines as a bond approaches maturity.

The Black model and interest rates

The Black model can also be used to price European short-term interest rate options. It prices these in relation to the forward interest rate at the expiry of the option rather than the cash market interest rate. Therefore, the volatility assumption that matters in this case is the volatility of the forward interest rate.

The Black model still makes questionable assumptions about the behaviour of interest rates over time. More complex pricing methods are based on modelling the evolution of interest rates, in a way that is consistent with the forward rates observed in the market. More advanced titles in the Wiley Finance series cover such matters.

CHAPTER SUMMARY

Implied volatility is the volatility assumption built into the actual dollar price of an option, and incorporates expectations about the future. A trader can check the implied volatility at which an option is being dealt and decide whether or not it represents good value. Generally speaking, if a trader thinks that the underlying asset is going to be more volatile than the assumption built into the premium being quoted for an option, then he or she should think about buying the option. In the opposite case, where the volatility assumption built into the market price of an option appears to be exaggerated, then the trader should consider shorting the option.

Other things being equal, the expected payout from a longer-dated option is greater than from a shorter-dated contract. A deeply out-of-the-money option has little time value, and the probability of exercise is low. Time value is generally highest around the at-the-money level. As an option moves increasingly in-the-money it acquires more and more intrinsic value, but time value steadily reduces. A deeply in-the-money call resembles a long position in the underlying. A deeply in-the-money put resembles a short position in the underlying.

European-style currency and equity index options can be priced using a modification to Black-Scholes. Interest rate options are more complex because interest rates and bond prices tend not to stray too far from their initial values. In addition, the volatility of a fixed interest bond tends to reduce as it approaches maturity and as its market price pulls back towards its par or redemption value.

15

Option Sensitivities: The ‘Greeks’

INTRODUCTION

Chapter 13 showed that, according to the Black-Scholes pricing model, the value of a European option on a share is determined by only five factors. The model inputs and the output are shown again in Figure 15.1.

Users of options are also interested in the **sensitivities** of the model. In other words, they are concerned with how changes to the inputs to the model affect the output value that is calculated.

This is what the ‘Greeks’ delta, theta, vega (or kappa) and rho measure. Technically speaking, they are **partial derivatives** of the option pricing model. This means that they measure the change in the calculated option value for a given change in *one* of the inputs to the model, all the other inputs remaining constant.

The most important ‘Greek’ is the delta. It measures the sensitivity of the option value to a small change in the price of the underlying. However, as discussed in Chapter 13, delta is not just a sensitivity number. It tells a dealer how much of the underlying to trade to hedge the risks involved in taking an option position.

Chapter 13 also showed that delta is not a constant. Given this fact, traders also use a ‘second-order’ Greek called gamma. This measures the change in delta for a given change in the spot price of the underlying.

DELTA (Δ OR δ)

Delta measures the change in the option value for a small change in the price of the underlying asset, assuming all other inputs to the model are held constant. It is often expressed as a ratio or a percentage. For example, suppose a bought call on a share has a delta of 0.5 or 50%. This means that if the price of the underlying share rises by one unit (such as one cent) then the option value will increase by half as much.

Traders often give the delta of an option position a positive or a negative value. The sign shows the directional exposure of the position to changes in the price of the underlying.

- **Long Call: Delta Positive**. The position increases (decreases) in value as the price of the underlying asset increases (decreases).
- **Short Call: Delta Negative**. The position loses value as the price of the underlying increases – it becomes more expensive to repurchase the call to close out the position. If the underlying falls in price the position gains in value because the call becomes cheaper to repurchase.
- **Long Put: Delta Negative**. The position increases (decreases) in value as the price of the underlying falls (rises).
- **Short Put: Delta Positive**. The position increases in value as the price of the underlying rises (the put becomes cheaper to buy back to close out the short position) and falls in value if the underlying price falls.

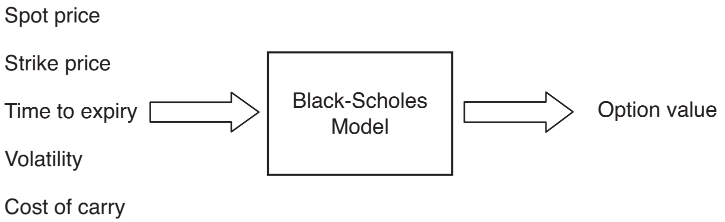

Figure 15.1 Black-Scholes option pricing model

In summary, the sign shows whether the position is a 'bull' or a 'bear' position. Positive delta means that the position makes money if the price of the underlying rises. In this sense it is similar to a long position in the underlying. Negative delta means the position makes money if the price of the underlying falls. In this sense it is similar to a short position in the underlying.

DELTA BEHAVIOUR

For a standard or 'vanilla' call, the value of delta lies between zero and one (0% and 100%). A deeply out-of-the-money long call has a delta approaching zero: it is highly insensitive to a small change in the underlying price. As the option approaches the at-the-money (ATM) point, its delta increases until it reaches about 0.50 or 50%. In other words, when it is ATM the option transmits around half of the price change in the underlying asset.

As the call moves increasingly in-the-money (ITM) its delta moves toward a limit of one or 100%. At this stage the option moves unit for unit with small changes in the price of the underlying. This is because an ITM option increasingly comes to resemble a position in the underlying security.

- **ITM Call**. A deeply in-the-money bought call option resembles a long position in the underlying.
- **ITM Put**. A deeply in-the-money bought put option resembles a short position in the underlying.

Delta as the slope on the option price curve

Delta can also be shown graphically. Figure 15.2 shows (dotted line) the value of a $100 strike call for different prices of the underlying, according to Black-Scholes, with other inputs to the pricing model kept constant. The graph also shows (solid line) the **slope** or tangent on the price curve when the option is at-the-money. This is delta. It is about 0.5. For a one cent change in the price of the underlying, the option changes in value by around half a cent.

Figure 15.2 confirms that the slope of the curve approaches zero when the call is deeply out-of-the-money; the option is insensitive to small changes in the price of the underlying. The graph also confirms that the slope of the curve approaches one when the call is deeply in-the-money. At that stage it behaves like a long position in the underlying; for small changes in the price of the underlying its value moves in step with that of the underlying.

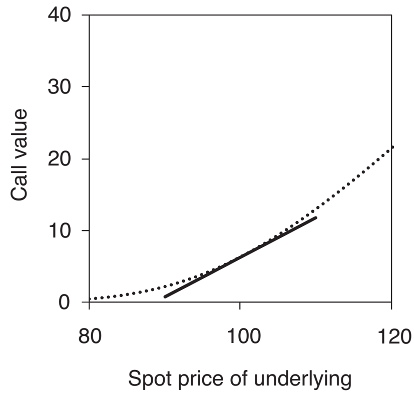

Figure 15.2 Delta as the slope on the option price curve

DELTA AS THE HEDGE RATIO

Delta is not only valuable as a sensitivity measure. As discussed in Chapter 13, it is used by option traders to hedge the risks on their trading books.

For example, suppose a trader has written an at-the-money call with a delta of 0.50. The option contract is written on 10 000 shares of the underlying. A useful way to look this contract is to calculate the **position delta**. For a small movement in the underlying share price, the call will move by half as much as the share. Therefore:

$$\text{Position delta} = -10\,000 \times 0.50 = -5000 \text{ shares}$$

The position is delta negative because the trader is short a call. If the share price rises the option will become more valuable. This would be a *loss* for the trader: it would cost more to repurchase the option than the premium price at which it was sold.

The position delta means that (for small movements in the price of the underlying) the trader has the same market exposure as a short position in 5000 shares. If the share price rises by (say) one cent the loss would be the same.

Constructing the delta hedge

To hedge this risk the trader can buy 5000 underlying shares. The delta of each purchased share is plus one (it moves fully in line with itself), so the net position delta is zero. Any losses on the short option position resulting from a small move in the underlying share price would be offset by profits on the long position in the stock.

For example, suppose the underlying share price rises by one cent. Then the trader will lose \$50 on the call.

$$\text{Loss on call} = -10\,000 \times \$0.01 \times 0.50 = -\$50$$

In this scenario the call has increased in value by \$50, and if the trader closes the short option position by buying the option back it would cost \$50 more than the premium at which it was sold. However the 5000 shares purchased to delta hedge the option position will have increased in value by a total of $50.

$$\text{Gain on shares} = 5000 \times \$0.01 = \$50$$

As discussed in Chapter 13, option portfolios that are hedged in this way so that they are not exposed to small movements in the price of the underlying security are said to be **delta-hedged** or delta-neutral.

THE EFFECTS OF CHANGES IN DELTA

Figure 15.2 confirms that the option delta (the slope of the option price curve) is not a constant. It depends on which point on the curve is taken.

> **Non Linearity**
>
> Delta is only a reliable measure of the change in the value of an option for *small* changes in the underlying price. In fact it assumes a **linear relationship** between the two. If the price of the underlying moves by a large amount then the actual option price change will be different from that predicted by delta.

Because option professionals use delta to manage the risk on their books, they are exposed to changes in their position delta. In the delta hedge example examined in the previous section the trader sells a call on 10 000 shares. The position delta is −5000 shares. In other words, for small movements in the share price, the profit and loss on the short option position will behave as if the trader is short 5000 shares – not 10 000, because the call moves half as much in price terms as the underlying share.

To delta hedge this position the trader can buy 5000 shares in the underlying. The hedge will work well for small movements in the underlying share price. The problem is that if the share price rises sharply the short call position will actually lose *more* money than predicted by the delta measure. This is the effect of **gamma** or convexity, the curvature in the option price graph. The 5000 shares purchased to hedge the risk will not match the losses on the option because the profit and loss profile on 5000 shares in the delta hedge is always linear.

Sensitivity of the delta hedge

Option traders tend to think of this problem in terms of the possibility that the delta hedge may have to be adjusted. In the above example the trader sells a call on 10 000 shares with a position delta of −5000 shares. The trader hedges the delta risk (the exposure to small movements in the underlying price) by buying 5000 shares.

Suppose that shortly after the call is sold and delta-hedged the share price rises suddenly, to the extent that, according to the pricing model, the option delta is now 0.51. In that case the position delta on the short call is equivalent to being short 5100 shares rather than 5000. It is more risky than before.

Now the trader has a tough decision to make. The first possibility is to leave things as they are (with only 5000 shares in the hedge portfolio) and hope that the share price falls back again. However the overall position will be badly *under-hedged* if the share price keeps rising – i.e. the losses on the call will greatly outweigh the offsetting profits on the 5000 shares in the delta hedge.

Alternatively, the trader can readjust the hedge by buying an additional 100 shares. But if the share price falls back again the trader will have *too many* shares in the hedge. In fact the trader will no longer be delta neutral but delta positive (with a 'bull' position in the underlying which will lose money if the share price falls further).

The trader can sell some or all of the additional 100 shares. However this will crystallize a loss on the hedge portfolio (buy at a high price, sell at a low price).

READJUSTING THE DELTA HEDGE

The last example illustrates a key problem with option trading. Normally traders do not sell large quantities of 'naked' options. It would be too dangerous. Instead, writers of options can manage their exposures to directional changes in the underlying share price by trading in the underlying stock.

The danger is that if the underlying is more volatile than predicted, then the delta hedge will become increasingly unstable. It may have to be readjusted at frequent intervals, realizing trading losses on the shares used in the hedge. The trick in writing options is to assess the **volatility** of the underlying accurately and price this into the premiums charged to buyers. If an option writer does this properly, then he or she should be able to readjust the delta hedge from time to time and still retain some of the initial premium as a profit.

Transaction Costs

An option trader will not actually rebalance the delta hedge every time the underlying price moves; transaction costs would quickly erode any profits. The skill lies in deciding what constitutes an *exceptional* movement in the underlying price that really should be covered, to guard against unacceptable losses.

In practice, also, many of the delta risks in an option book will tend to cancel out. For example, a short call is a **negative delta** position, but a short put is a **positive delta** position. If the underlying rises or falls by a small amount the profits and losses will offset each other to some extent. Normally it is the residual delta risk in the trading book that is covered by trading in the underlying asset.

GAMMA (Γ OR γ)

Because delta is not a constant, and because this fact can lead to losses on short option positions, dealers use an additional 'Greek' called **gamma** to measure changes in option delta. It is a useful indicator of how stable or otherwise a delta hedge is likely to be.

Gamma Defined

Gamma measures the change in the delta of an option for small changes in the spot price of the underlying, all other inputs to the pricing model kept constant.

Graphically, gamma is a measure of the **curvature** (or convexity) in the relationship between the value of an option and the spot price of the underlying, as shown in a graph such as

Figure 15.2. The greater the amount of curvature, the more rapidly delta (the slope or tangent on the option price curve) will change.

Position gamma

Suppose a trader sells a call option with a delta of 0.50. The call is written on 10 000 shares, so the position delta is −5000 shares. Suppose also that the option gamma indicates that for a one cent rise in the underlying price the delta would change to 0.501. The profits and losses on the option position would now behave as if the trader was short 5010 shares rather than 5000. Therefore:

$$\text{Position gamma} = -10 \text{ shares}$$

Assuming the trader bought 5000 shares at the outset to hedge the delta risk, this gamma measure tells the trader to buy a further 10 shares to rebalance the hedge if the price of the underlying rises by one cent.

GAMMA AND THE SPOT PRICE OF THE UNDERLYING

Figure 15.3 shows the relationship between the delta of a three-month $100 strike call and the spot price, all the other inputs to the pricing model kept constant. It shows that delta ranges between zero and one.

Figure 15.3 also shows that delta changes *most rapidly* when the option is around the at-the-money level, in this case $100. Here the delta is most sensitive to changes in the price of the underlying, i.e. the gamma is at its highest. Options tend to be at their most sensitive when they are at-the-money. It is the ‘pivot’ point.

By contrast the change in delta (the gamma) is relatively low when the call is out-of-the-money (OTM) or in-the-money (ITM). A deeply OTM call has a delta close to zero. It is unlikely to be exercised and is insensitive to small changes in the price of the underlying. Furthermore, the delta is more or less anchored at close to zero, and the value is unlikely to change unless there is a sharp rise in the price of the underlying.

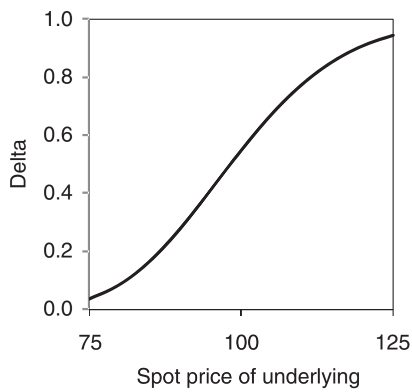

Figure 15.3 Delta curve for $100 strike call with three months to expiry

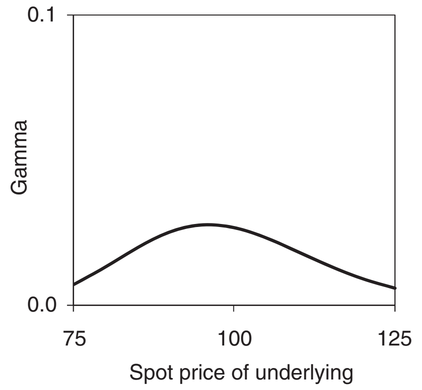

Figure 15.4 Gamma for a three-month call option for different spot prices

A deeply ITM call has a delta close to one. It is highly likely to be exercised and behaves rather like a position in the underlying share. The delta is close to one, and the value is more or less anchored at that level. It would take a sharp fall in the price of the underlying to affect the situation.

Gamma curve

Figure 15.4 shows the same phenomenon. It is a graph of the relationship between the gamma of the above call option and the spot price, all other inputs to the pricing model kept constant. The graph confirms that gamma is highest when the call is around the ATM level, and lowest when it is deeply OTM or ITM.

GAMMA AND TIME TO EXPIRY

Figure 15.5 shows the relationship between the spot price of the underlying and the delta of the $100 strike call explored above, but this time when the option has only *10 days* rather than three months to expiry.

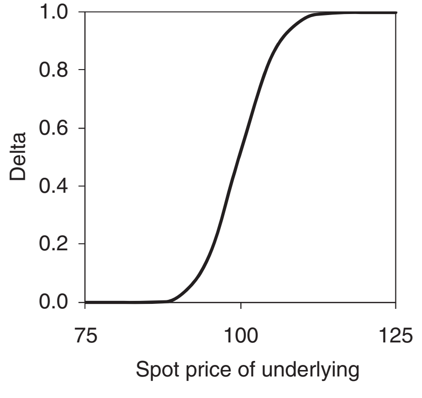

Figure 15.5 Delta curve for $100 strike call with 10 days to expiry

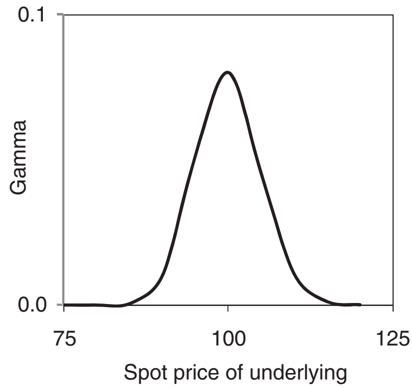

Figure 15.6 Gamma and the spot price for a 10-day call option

Figure 15.5 shows that the gamma has increased if the option is at-the-money, but reduced if it is OTM or ITM. With relatively little time to expiry, it is highly likely that the call will not be exercised if it is deeply OTM and that it will be exercised if it is deeply ITM. The deltas are close to zero and one respectively, and it would take a major change in the price of the underlying to change that situation. Meantime, there is more uncertainty about the eventual fate of the option if it is still ATM with only 10 days remaining until maturity.

Gamma curve

Figure 15.6 illustrates the same point, by examining directly the relationship between the option gamma and the spot price of the underlying when the call has only 10 days to expiry. Note how much more 'bunched' the curve is compared to the gamma curve in Figure 15.4 when there are three months to expiry.

The phenomenon of rising gamma on ATM options as they approach expiry matters particularly to a trader who is short options. This is because the more gamma in the position, the more unstable a delta hedge is liable to be.

As shown before, when a trader is short options and keeps adjusting the delta hedge by dealing in the underlying shares, this can crystallize a series of trading losses. If the share price rises the writer of a call has to add more shares to the hedge portfolio to restore delta neutrality. Then if the stock price falls back again the trader has to sell some or all of those additional shares at a lower price (and at a loss).

THETA (Θ)

Theta measures the change in the value of an option as time elapses, all other inputs to the pricing model remaining the same.

To illustrate the concept, Figure 15.7 shows the changing value of a three-month ATM call option with a strike of $100 as the option approaches expiry. All the other inputs to the pricing model have been kept constant: the strike, the price of the underlying, the volatility assumption and the carry cost.

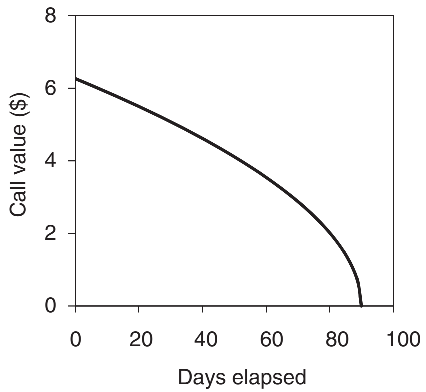

Figure 15.7 Time value decay

Figure 15.7 shows that the option *loses* time value as it approaches expiry. With less time remaining, there is less chance that the option will expire in-the-money. Theta measures the rate of decay in the time value of an option. It is the slope or the tangent at any given point on the curve. The option in Figure 15.7 is at-the-money throughout, and ATM options (especially short-dated ones) tend to have relatively high theta values.

Measuring theta

Theta is negative for long calls and puts – the position loses value every day. For opposite reasons theta is positive on short option positions. Every day that elapses (other inputs to the pricing model remaining constant) options tend to lose value. This is good news for a trader with a short position, because the contracts get cheaper to buy back to close out the position.

Figure 15.7 also shows that the rate of time decay on the ATM call actually *accelerates* as time goes by. With zero days elapsed (three months to expiry) the call has a theta of roughly −\$0.04. This means that if a further day goes by the call will lose about four cents in value, assuming that all the other inputs to the pricing model remain constant. The theta with 80 days elapsed (10 days to expiry) is roughly −\$0.1. If a further day elapses at that stage the call will lose about 10 cents in value, other things being equal.

These numbers are per share. If the option contract is written on (say) 10 000 shares the values are increased in proportion.

VEGA OR KAPPA (κ)

The value of an option is also sensitive to the assumption made about the volatility of the underlying. This sensitivity is measured by vega. Vega measures the change in the option value for (typically) a 1% change in the assumed volatility of the underlying, other inputs to the pricing model remaining constant.

Buying an option is sometimes called a long volatility or **long vega** position. If the volatility assumption used to price the option increases, the contract will become more valuable. This applies to call and put options.

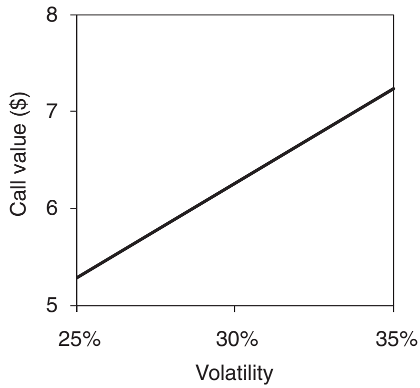

Figure 15.8 Option value against volatility

Conversely, a trader who is short options hopes for declining volatility, because the options will become cheaper to repurchase. (Vega is not in fact a Greek letter; some people use the Greek letter **kappa** instead.)

Vega graph

Figure 15.8 is a graph of the value of a $100 strike ATM three-month call priced using different volatility assumptions. As volatility increases the value of the option increases in a more or less linear fashion.

The vega of this particular option is about $0.2. This means that for a 1% change in volatility (all other inputs to the pricing model remaining constant) the option will increase or decrease in value by about 20 cents. As with the theta value in the previous section, this is on a per share basis. Vega is the slope on the line in Figure 15.8 showing the relationship between volatility and option value.

RHO (ρ)

The final 'Greek' considered here is rho. Rho measures the change in an option's value (all other inputs to the model remaining constant) for a given change in interest rates, typically either 0.01% p.a. or 1% p.a.

Figure 15.9 shows the value of a $100 strike ATM call as interest rates rise. It is a linear relationship and rho is the slope of the line in the graph. In this particular example rho is $0.12. This means that for a 1% increase in the interest rate the call option value (all other inputs remaining constant) increases by 12 cents. Again this is on a per share basis and has to be increased in proportion to the number of shares in the option contract.

Rho on call options

The option pricing model assumes that when an option is written a riskless hedge can be put in place using the delta measure. In the case of a call option, delta tells the writer how many of the underlying shares to buy to cover the exposure. The model assumes, in effect, that this

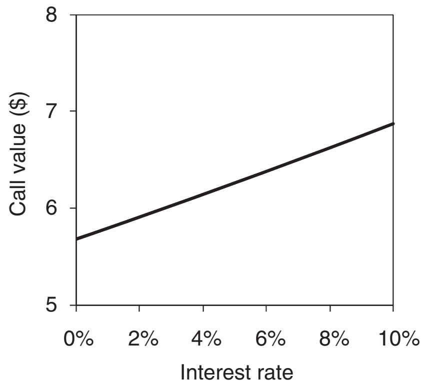

Figure 15.9 Option value against interest rates

is funded through borrowing, offset by any dividend income received on the shares. All other things being equal, then, when interest rates rise the value of call options also tends to rise. The writers of calls pass on their higher funding costs to the buyers.

Rho on put options

On the other hand if interest rates rise the value of put options will tend to fall. Writers of put options are exposed to falls rather than rises in the price of the underlying share. To hedge this delta exposure they can run short positions in the underlying. As interest rates rise, they will earn more money by investing the cash received from selling the shares short, and can afford to pass the benefits on to the buyers of the puts.

SUMMARY OF GREEKS

Table 15.1 summarizes the 'signs' of the Greeks for four basic option strategies: long or short a call; long or short a put.

To take one example from Table 15.1, a long call has positive delta (it profits from a rise in the share price). It has positive gamma or convexity, which means that the profits accelerate in a more than linear fashion as the price of the underlying rises. As the underlying price falls the losses decelerate because the most money that can ever be lost is the initial premium paid. The position is negative theta because of the time value decay effect. It is positive vega and rho because the call will become more valuable if volatility increases or interest rates rise.

Table 15.1 Signs of the 'Greeks' for basic option strategies

Strategy	Position delta	Position gamma	Position theta	Position vega	Position rho
Long call	Positive	Positive	Negative	Positive	Positive
Short call	Negative	Negative	Positive	Negative	Negative
Long put	Negative	Positive	Negative	Positive	Negative
Short put	Positive	Negative	Positive	Negative	Positive

CHAPTER SUMMARY

The change in the value of an option for a small change in the price of the underlying is measured by delta. Delta is the slope or tangent on the option price curve. It is also the hedge ratio, the number the trader uses to decide how much of the underlying to trade to manage the risk on an option position. Delta is not a constant and is most unstable when an option is at-the-money and approaching expiry.

Theta measures the change in the value of an option as time elapses. It is negative for bought option contracts. Vega or kappa measures the change in the value of an option for a given change in volatility. It is positive for bought calls and puts. Rho measures the sensitivity of the option value to a change in interest rates. It is positive for long calls and negative for long puts.

The first-order 'Greeks' delta, vega, theta and rho are partial derivatives of the option pricing model. This means that they assume that only one factor used to determine the value of an option is changed, and the other inputs to the model are kept constant. Gamma is a 'second-order' Greek: it measures the change in one of the first-order Greeks (the delta) for a small change in the spot price of the underlying.

16

Option Trading Strategies (1)

INTRODUCTION

A long (bought) call is a **bull strategy** – if the price of the underlying asset rises the call increases in value. Conversely, a long put is a **bear position** and profits from a fall in the value of the underlying. However, these are far from being the only possibilities on offer. Options are extremely flexible tools that can be used in many combinations to construct strategies with widely differing risk and return characteristics.

Nowadays even more tools are available due to the creation of **exotic options** – products such as barriers and compound options encountered previously. In this and subsequent chapters further new instruments are introduced: average price options, digital options, forward start options, choosers and cliquet (ratchet) options designed to lock in intervening gains resulting from movements in the price of the underlying.

The Structuring Desk

The structuring desk of a modern securities business is where these various products are brought together. The firm's sales and marketing staff speak to a client about trading, investment or hedging needs, map out the problem, and ask their colleagues in the structuring desk to help to design an appropriate solution. There is considerable opportunity for creativity in the process.

The first set of ideas presented to a client may not be very appealing because the premium cost is too high, or there are unattractive currency exposures, or there are tax implications, or the levels at which the strategy makes and loses money do not coincide with the client's opinion on where the market is moving.

There are, however, many ways of adjusting the structure. Strikes can be changed or additional options incorporated that affect the premium or the overall risk/return characteristics. Eventually a solution is assembled that is appropriate for the client. The various components – the individual options and other derivative products from which it is constructed – are priced. Once the solution is agreed and signed off, the traders manage the risks that the house acquires as a result of doing the deal with its client.

BULL SPREAD

A **bull spread** is a good strategy to use when a trader is fairly confident that the underlying price will rise, but wants to limit the downside risk.

Suppose a share is currently trading at \$100. A trader buys a three-month call on the share struck at \$100 and pays a premium of \$6.25 per share. The trader also sells a three-month \$105 strike call on the same share and earns a premium of \$4.25 per share. Figure 16.1 shows the expiry payoff profile for the combination strategy.

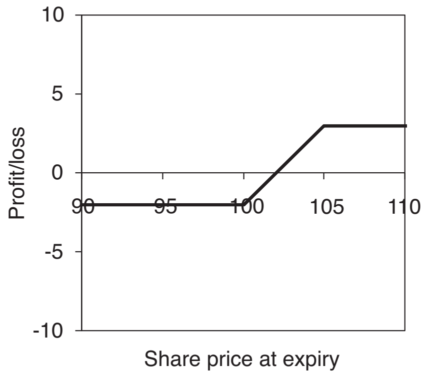

Figure 16.1 Bull spread expiry payoff profile

The maximum loss on the bull spread at expiry is the net premium of \$2. The maximum profit is \$3 per share. This is achieved when the share price reaches \$105. It comprises a profit of \$5 on the \$100 strike long call, less the net premium. At price levels above \$105 any gains on the \$100 strike call are exactly offset by losses on the \$105 strike short call. (For simplicity this analysis ignores the fact that the net option premium is paid up-front while any profit from exercise is achieved at expiry; the premiums have also been rounded.)

Use of Bull Spreads

A bull spread is a sensible strategy to use when a trader expects a modest rise in the price of the underlying. It has advantages compared to buying a call on its own. The net premium cost is lower. The maximum loss is less, and the level at which the share has to trade at expiry to break even is lower. The position is normally set up with positive delta and with fairly neutral values for gamma, theta and vega.

Bull spread with puts

The bull spread just explored could also be assembled by selling an in-the-money put struck at \$105, and at the same time buying an out-of-the-money put struck at \$100 to limit the losses if the share price falls. The advantage of constructing the trade in this way is that a positive net premium would be received at the outset. Taking into account borrowing and lending costs, however, the eventual net profits and losses would be identical compared to setting up the strategy with call options.

BULL POSITION WITH DIGITAL OPTIONS

The net premium payable on the bull spread in the previous section was \$2. An alternative is to buy a **digital** or binary call option on the underlying share. For roughly the same cost, the trader could buy a three-month **cash-or-nothing** (CON) digital call on the share struck at \$105 and with a cash payout of \$6.

The CON call works as follows: if at expiry the share price is above \$105 and the option is in-the-money then the option payout is \$6; otherwise it is zero. Figure 16.2 illustrates the

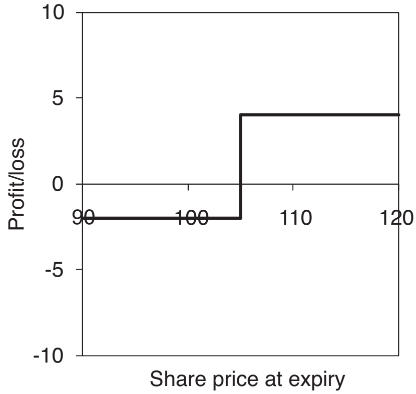

Figure 16.2 Net profit/loss on CON call at expiry

net profit and loss on the CON call at expiry, net of the $2 premium paid for the option. It is either a net profit of $4 or a net loss of $2.

With the CON call the nature of the bet is a little different to the bull spread explored earlier. It is for someone who is convinced that the share price is going to be trading above (but not much above) the strike of $105 at expiry. If the share price is in the range $100 to $105 the CON call pays out nothing at all – unlike the bull spread – but if the share price is higher than $105 then the entire cash payout of $6 is due.

The payout on the CON call *could* be increased, but at the expense of additional premium. For example, a cash-or-nothing call with similar terms but a payout of $12 would cost about twice as much in premium.

Other Digital Options

An **asset-or-nothing** (AON) option pays out the value of the underlying asset if it expires in-the-money, otherwise nothing. Digital options can also be structured such that they only pay out if the underlying has hit a threshold or barrier level during a defined period of time.

SPOT PRICE AND CON VALUE

The behaviour of a CON digital option in response to changes in the spot price of the underlying is interesting.

This is illustrated in Figure 16.3. The dotted line in the graph shows the value of a three-month $105 strike standard or 'vanilla' call option. The solid line is a three-month $105 strike cash-or-nothing call with a cash payout of $6. In both cases all the other inputs to pricing the options are kept constant, and only the spot price is changed. In particular, there are still three months remaining to the expiry of the two options.

Figure 16.3 shows that as the share price increases, the value of the vanilla call continues to rise, and begins to behave rather like a long position in the underlying. However, the value of the CON call converges on the cash payout (actually its present value). The probability of exercise is approaching 100% but the payout is fixed at $6 and cannot be any higher regardless of the value of the underlying in the spot market.

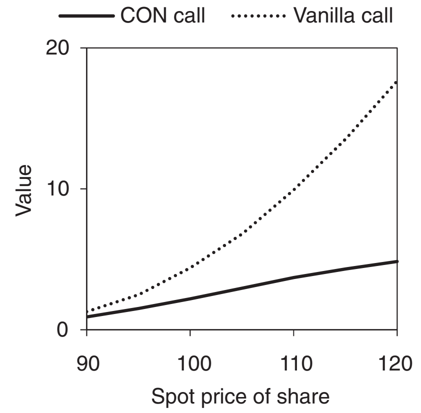

Figure 16.3 Value of CON call for different spot prices

BEAR SPREAD

A bear spread strategy is useful when a trader is *moderately* bearish about the underlying. It generates a capped profit when the underlying price falls, but suffers a maximum loss if the price rises.

Figure 16.4 illustrates a bear spread on a share currently trading at \$100. It is constructed by buying a three-month at-the-money put struck at \$100 costing \$5.5 per share, and selling a three-month out-of-the-money put on the same share struck at \$95 for a premium of \$3.5 per share. The net premium payable is \$2 per share.

Figure 16.4 shows that if the share price at expiry is \$100 or above then neither option is exercised and the maximum loss is the net premium of \$2. At share prices below \$100 the long put has intrinsic positive value. However the profit on the strategy is capped at \$95 when the strike of the short put is reached. The maximum profit on the bear spread at expiry is \$3.

The bear spread trade could also be assembled by shorting a call struck at \$95 and buying a call struck at \$100.

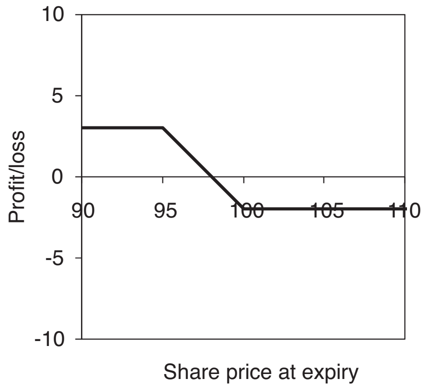

Figure 16.4 Bear spread expiry payoff profile

Closing out before expiry

It is not necessary to maintain a position like this all the way to the expiry of the two options. It can always be closed out by selling a \$100 strike put and buying a \$95 strike put on the same underlying with the same time to expiry. Whether this realizes a profit or a loss depends on what has happened to the share price in the meantime, and on changes in the other factors that determine the values of the two options.

THE GREEKS FOR THE BEAR SPREAD

The 'Greeks' for the bear spread are useful in giving an indication of the potential risks and returns from the trade. (For more information on the Greeks and how they are used by option traders see Chapter 15.)

The Greeks for the strategy are simply the sums of the values of the two components, the long put struck at \$100 and the short put struck at \$95. As always, the assumption is that all other inputs to the pricing model remain constant. For example, the delta assumes that the time to expiry, volatility and net carry remain the same, and only the spot price changes. The vega assumes that only the volatility is changed and other factors are held constant.

The 'Greeks' for the bear spread are as follows. This is on a per share basis. If a trader buys and sells puts on (say) 100 shares the profit and loss values are increased in proportion.

- **Delta = −0.13.** For a \$1 fall (rise) in the spot price the trade will produce a profit (loss) of about \$0.13. The fact that delta is negative shows that this is a bear position – it profits from a fall in the share price.
- **Gamma = 0.003.** For a \$1 rise in the spot price the delta will change from −0.13 to about $-0.13 + 0.003 = -0.127$. The gamma is low because the gammas of the long and short put options largely cancel out.
- **Theta = −0.002**. If one day elapses (all other factors remaining constant) the loss on the bear spread will be approximately \$0.002. Again, this is a small number. The strategy consists of a long and a short three-month put option and so the theta effects more or less cancel out.
- **Vega = 0.019**. If volatility increases (decreases) by 1% p.a. the bear spread will increase (decrease) in value by about \$0.019. The strategy is not particularly sensitive to changes in volatility.
- **Rho = −0.037**. If interest rates rise (fall) by 1% p.a. the bear spread will decrease (increase) in value by about \$0.037. Again, the rho is not high. The values on the short and long puts just about cancel out.

The key exposure here is the negative delta. It tells us that this is indeed a bear strategy. The other Greeks are not high values, although the slightly positive gamma is a small benefit. When the gamma on an option strategy is positive this is an example of what is sometimes called a 'right-way' exposure.

With the bear spread, the positive gamma means that if the price of the underlying falls, the strategy will behave like *more* of a short position in the underlying (which is a good thing in that circumstance). On the other hand if the price of the underlying rises the strategy will behave like *less* of a short position in the underlying (which is also a good thing in that circumstance).

However, the gamma effect is limited in this example since one option is bought and another is sold.

A high gamma trade

A more clear-cut example of a **positive gamma** position is a long call that is at-the-money and approaching expiry (a put would display similar characteristics). The delta of the call will be around 0.5. This means that if the share price rises by a small amount the call will increase in value by about half that amount.

The position will also have positive gamma. If the spot price keeps rising, the delta will become *more* positive, to the limit of 1, at which point the call will behave just like a long position in the underlying and move in step with the price of the underlying.

To put it another way, the more the share price rises, the greater the effective exposure to the share price the option provides. However if the spot price falls, the delta will become *less* positive (to the limit of zero) at which point there is no effective exposure to movements in the price of the underlying.

Later examples show that **negative gamma** positions are 'wrong way' exposures. The exposure to changes in the price of the underlying (whether it rises or falls) tends to move in exactly the wrong direction.

PUT OR BEAR RATIO SPREAD

The bull and bear spreads examined above illustrate the payoff at expiry of strategies where options are bought and sold on an equal number of shares. A **ratio spread** is a strategy where this is not the case.

Figure 16.5 shows the expiry payoff profile of a **put ratio spread**. This example combines a long in-the-money put struck at \$105 plus a short out-of-the-money put struck at \$95 on double the number of underlying shares. The premium paid on the long put is \$8.5 per share. The premium received on the short put is \$3.5 per share, or \$7 on two shares. The spot price of the underlying is \$100. Both options have three months to expiry.

Figure 16.5 shows that if the share price at expiry is \$105 or above neither option is exercised and the loss is the net premium of \$1.5. If the share price is between \$105 and \$95 the long put is exercised. The maximum profit is \$105 − \$95 − \$1.5 = \$8.5.

Figure 16.5 also shows that, unlike the bear spread in Figure 16.4, if the share price is below \$95 at expiry the profit and loss line does not flatten out. It starts to fall, and crosses the zero

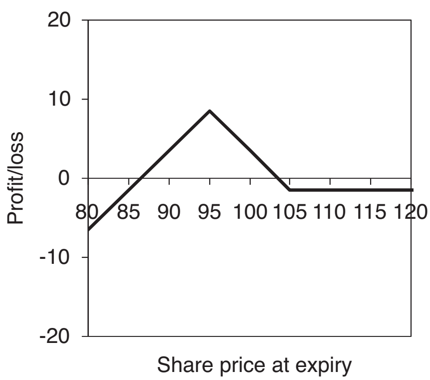

Figure 16.5 Put ratio spread expiry payoff profile

point again when the underlying share is trading at $95 − $8.5 = $86.5. The maximum loss is made when the share is worth nothing.

Use of Put Ratio Spread

The strategy is useful for a trader who is moderately bearish but who thinks it unlikely that the share price will fall below $95. The trader could also sell a $95 strike put on *three* or even more shares for every one share in the long put option position. This would produce a positive initial premium. However it would also greatly increase the downside risk. The risk would be that the share is trading well below $95 at expiry.

LONG STRADDLE

A long straddle is a bet on rising volatility levels. It consists of a long call and a long put on the same underlying with the same strike and time to expiry. The strike is often set around the at-the-money level.

Suppose a trader buys a straddle on a share that is currently trading at $100. The straddle consists of two elements.

- **Long Call Strike** = $**100**. The call has three months to expiry and the premium is $6.25 per share.
- **Long Put Strike** = $**100**. The put has three months to expiry and the premium is $5.5 per share.

The total premium the trader has to pay up-front is therefore $11.75 per share. Figure 16.6 shows the payoff profile for the long straddle trade at expiry, i.e. three months after the purchase date.

The disadvantage of the strategy is clearly that two lots of premium have to be paid up-front. On the other hand, this is also the maximum loss. The break-even points at expiry are reached when the underlying is trading at $111.75 (the strike plus the total premium) or at $88.25 (the strike minus the total premium).

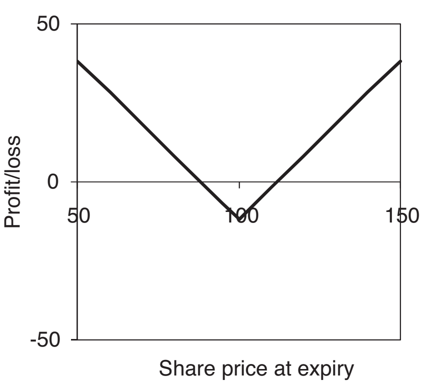

Figure 16.6 Expiry payoff profile for long straddle

As long as the share price has broken out of that range, in *either* direction, the long straddle strategy shows a profit.

The long straddle is suitable for someone who considers that the share is set to rise or fall sharply over the next few months, but is not sure of the direction the movement will take. The stimulus could be the imminent release of financial results that are likely to impact on the share price, positively or negatively; or simply a period of uncertainty ahead, which will move the price out of its current trading range.

LONG STRADDLE CURRENT PAYOFF PROFILE

It is not necessary to run a long straddle position all the way to expiry. It can be unwound by selling the call and the put option back into the market.

Figure 16.7 shows the profit and loss on the strategy, but this time not at expiry, but in response to *immediate* changes in the spot price of the underlying on the day it is put in place, i.e. with three months remaining to expiry. This is called a **current payoff profile**. The profits and losses are calculated by working out what the two options could be sold for at each spot price and subtracting from this the \$11.75 premium initially paid for them. The volatility assumption and the carry cost are held constant throughout.

Positive gamma

The curvature in the graph in Figure 16.7 is a sign that we are dealing with a **positive gamma** position. This is good news because it means that the position is a 'right-way' exposure. At the outset the delta on a long straddle, with at-the-money options, is normally quite close to zero. For small movements in the price of the underlying the profits and losses on the call and the put tend to cancel out. For example, if the share price rises the call moves in-the-money and the put moves out-of-the-money. These effects are offsetting.

However things improve greatly when the price of the underlying share rises or falls by a larger amount.

- **Spot Price Rises**. The straddle will become increasingly **delta positive**, i.e. it will behave increasingly like a long position in the underlying. The call moves more and more

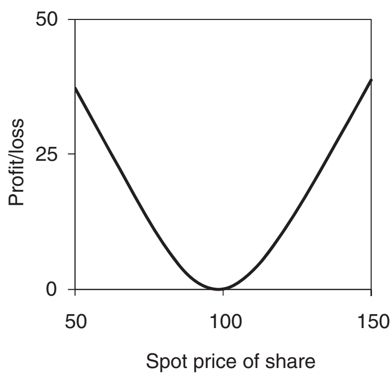

Figure 16.7 Current payoff profile of long straddle

in-the-money. It is true that the put loses value, but the maximum loss on the put is the initial premium paid for the option.

- **Spot Price Falls**. The straddle will become increasingly **delta negative**, i.e. it will behave increasingly like a short position in the underlying. The put moves more and more in-the-money. It is true that the call loses value, but the maximum loss on the call is the initial premium paid for the option.

In other words, for larger rises in the spot price, the profit on the call more than offsets the loss on the put. For larger falls in the spot price, the profit on the put more than offsets the loss on the call. There is an asymmetry here, and this is the happy effect of having a positive gamma (or convexity) position.

POTENTIAL RISKS WITH A LONG STRADDLE

Figure 16.7 suggests that if the share price falls just after the trade is put in place the long straddle makes money and if it rises the trade also makes money! There must be a catch somewhere.

The snag is that the trade is **long vega** and **short theta**. Long vega means that if the volatility of the underlying share falls then the two options will tend to become less valuable. Short theta indicates that every day that elapses, other things being equal, the options will tend to lose value. This means that if the long straddle is unwound by selling the call and the put back into the market this may realize a trading loss.

To illustrate the risks involved here, Figure 16.8 shows the current payoff profile for the long straddle after 30 days have elapsed. It is also assumed that the volatility of the underlying has declined by 5%. The graph shows that if the spot price is still around the \$100 strike level after 30 days (with a 5% fall in volatility) then the straddle has lost value. If it is unwound by selling the call and the put back into the market this will crystallize a trading loss. The options are now worth less than the \$11.75 originally paid for them.

In Figure 16.8 the option value curve has shifted downwards because the two options have lost time value. Roughly speaking, the spot price of the underlying would have to have risen

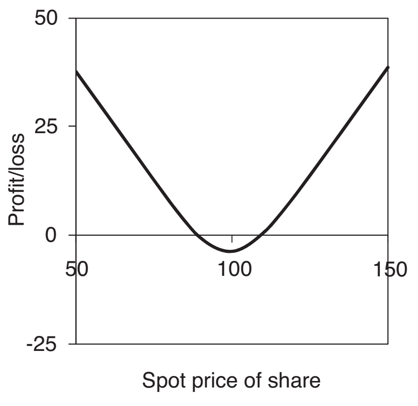

Figure 16.8 Current payoff profile of long straddle after 30 days with 5% fall in volatility

or fallen by about $10 to compensate for the losses resulting from falling volatility and time decay (the vega and the theta effects).

CHAPTER SUMMARY

Options can be combined to construct a huge array of different trading strategies. One popular strategy is a bull spread which makes a capped profit if the price of the underlying rises but only suffers a limited loss if the price falls. An alternative to setting up a bull spread is to buy a cash-or-nothing (CON) digital call option. This pays out a fixed amount of cash if it expires in-the-money, otherwise it expires worthless.

A bear spread trade makes money when the price of the underlying falls. There is a maximum profit and a maximum loss. A ratio spread is a different kind of deal, in which options are bought and sold on different numbers of underlying shares. It can generate positive premium but the risks can be substantial.

A long straddle combines a long call and a long put on the same underlying with the same expiry date. It is a bet that the volatility of the underlying will rise. If it does so then the straddle can be sold back into the market at a profit. The strategy can lose money if volatility declines and it also suffers from the fact that the two options tend to lose time value as they approach expiry.

17
Option Trading Strategies (2)

INTRODUCTION

The previous chapter introduced some trading strategies which use options in various combinations. This chapter continues the subject. It focuses firstly on volatility trades using chooser options and short straddle and strangle positions. There is a discussion on a well-known index of stock market volatility. Finally, there is an example of a time or calendar spread trade which exploits the time decay (theta) effect with options.

CHOOSER OPTION

The problem with the long straddle explored in Chapter 16 is that premium has to be paid on both the call and the put option. The strategy also suffers from time value decay and is sensitive to declining volatility. The time decay will become more exaggerated if the options are still around the at-the-money level as the expiry date approaches. One way to reduce the premium is to buy a **chooser option** instead of a straddle.

> **Chooser Option Defined**
>
> The buyer of a chooser has the right to decide, after a set period of time, whether it is to be a call or a put option on the underlying asset.

Figure 17.1 shows the current payoff profile for a long chooser on a share struck at-the-money at \$100. The option has three months to expiry. However, after one month the owner must decide whether it is to be a call or a put. In either case the strike will be \$100 and the time remaining to expiry at that point will be two months.

The current payoff profile shows the profit and loss that would be realized if the chooser is sold back into the market *on the day that it is purchased*. This is based on revaluing the chooser option for a range of different spot prices, holding all the other inputs to the pricing model (the volatility etc.) constant.

Value of the chooser

The value of the long chooser at any time is the value of the call or the put option it can become, whichever is the greater of the two. If the spot rises (falls) from the initial level the chooser will behave like a long call (put) since it is most likely that that will be selected. The gamma (the curvature in the graph in Figure 17.1) is positive. This tells us that we have a 'right-way' exposure. The more the spot price rises (falls) the more the chooser will behave like a long (short) position in the underlying and its delta will move towards $+1$ (-1).

The chooser might sound like an extremely exotic structure, although in fact it can be assembled from quite standard components and is therefore quite easily priced. Ignoring the

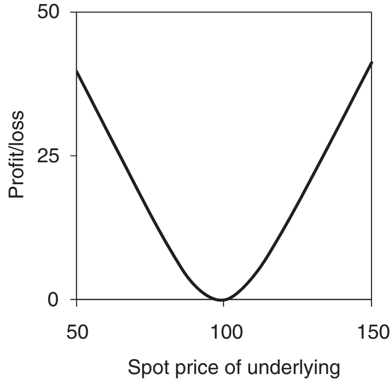

Figure 17.1 Current payoff profile for a three-month chooser struck at $100

complications of carry, the chooser just considered could be replicated by buying a three-month put and a one-month call, both struck at $100.

SHORT STRADDLE

A short straddle combines a short call and a short put on the same underlying with the same strike price and the same time to expiry. It is a **short volatility** (short vega) trade, since if volatility declines then (other factors remaining constant) both the options combined in the strategy will fall in value. The short straddle can then be closed out by repurchasing the options for less than the premium at which they were sold.

The following example is the exact reverse of the long straddle discussed in Chapter 16. The underlying share is the same, and is currently trading at $100. The difference is that this time the trader sells the two options and therefore earns the initial premium. The components of the short straddle are as follows:

- **Short Call Strike** = $**100**. The call has three months to expiry and the premium is $6.25 per share.
- **Short Put Strike** = $**100**. The put has three months to expiry and the premium is $5.5 per share.

Expiry payoff profile

Figure 17.2 shows the expiry payoff profile for the short straddle. The maximum profit is the combined premium of $11.75, achieved when the underlying is trading at $100. The seller of the straddle is looking for a dull market, in which the underlying trades in a narrow range. In this particular example, the strategy is profitable at expiry as long as the underlying share is trading above $88.25 and below $111.75.

SHORT STRADDLE CURRENT PAYOFF PROFILE

Figure 17.2 reveals that the short straddle is a risky trade. In fact the maximum loss is potentially unlimited. However, it is not necessary to run the strategy all the way to expiry. It

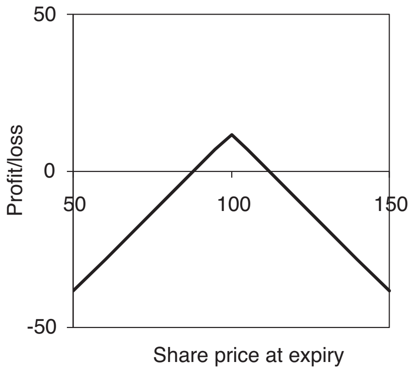

Figure 17.2 Expiry payoff profile for short straddle

can be unwound at any time by buying back the call and the put option in the market. Given the risks involved, this is a common approach.

It is useful to look at the **current payoff profile** for the short straddle. This shows the profit or loss, not at expiry, but in response to *immediate* changes in the spot price of the underlying. The profits and losses are calculated by working out what it would cost to repurchase the two options in the straddle for a range of different spot prices, and then subtracting this from the \$11.75 premium initially received for selling them. All the factors that determine the current value of the straddle other than the spot price are held constant.

Figures 17.3 and 17.4 show the current payoff profiles for the short call and for the short put on their own. Figure 17.5 then adds these together to show the current payoff profile for the short straddle. Profits and losses are worked out assuming that there are still three months until expiry and that volatility is unchanged.

Negative gamma

The curvature in Figure 17.5 reveals the fact that the short straddle is a **negative gamma** position. This is a classic 'wrong-way' exposure. The strategy loses money whether the share

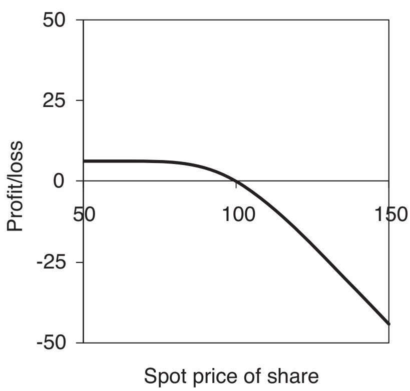

Figure 17.3 Current payoff profile for short call

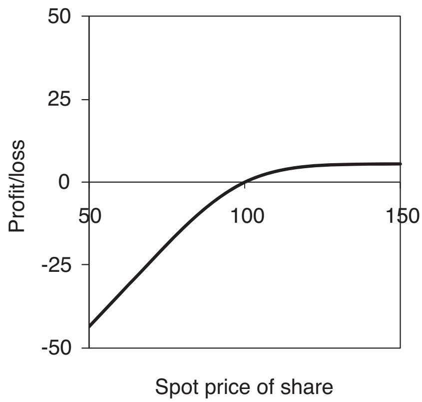

Figure 17.4 Current payoff profile for short put

price rises or falls. Not only that, the losses actually begin to *accelerate* if there are larger movements in the price of the underlying share.

- **Share Price Rises**. The losses on the short call will start to exceed the profit on the short put (the maximum of which is the initial premium at which it was sold). The delta of the straddle will become increasingly negative. Eventually the straddle will behave just like a short position in the underlying.
- **Share Price Falls**. The losses on the short put will start to exceed the profit on the short call (the maximum of which is the initial premium at which it was sold). The delta of the straddle will become increasingly positive. Eventually the straddle will behave just like a long position in the underlying.

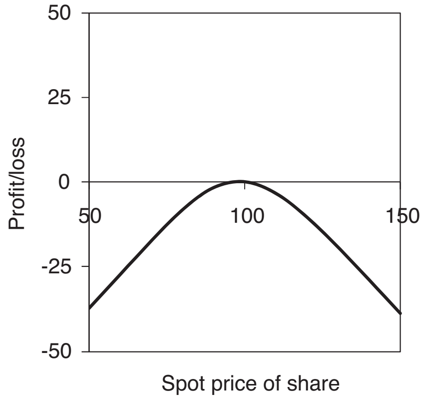

Figure 17.5 Current payoff profile for short straddle

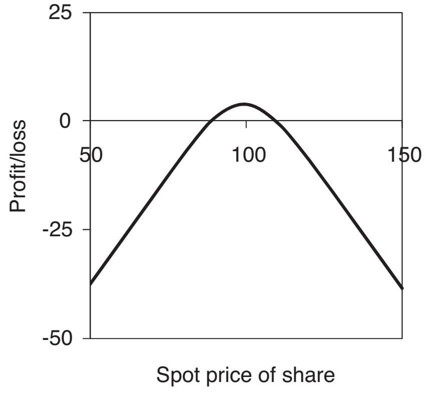

Figure 17.6 Current payoff profile of short straddle after 30 days with 5% fall in volatility

POTENTIAL PROFITS WITH A SHORT STRADDLE

Figure 17.5 shows quite clearly that the short straddle trade loses money if the share price moves in either direction, except if the movement is very small. How, then, does it make money?

The answer is that the trade is **short vega** and **long theta**. Short vega means that if the volatility of the underlying share falls then (other things being equal) the two options will tend to become less expensive. Long theta means that the same thing happens as time elapses. In this case the seller of a straddle actually *wants* the two options to lose value because the short straddle strategy can then be unwound at a profit. This is achieved by repurchasing the call and the put option that were used to construct the position.

Current payoff recalculated

To illustrate the point, Figure 17.6 shows the current payoff profile for the short straddle after 30 days have elapsed. It is also assumed here that the volatility of the underlying has declined by 5%. The graph shows that if the spot price is still around the \$100 strike level after 30 days (with a 5% fall in volatility) then the short straddle is now profitable. It was originally sold for a premium of \$11.75 per share. It would cost less than that to close the position by repurchasing the call and put options used to construct the strategy.

In Figure 17.6 the option value curve has shifted upwards because the two options have lost time value. Roughly speaking, the spot price of the underlying would have to have risen or fallen by about \$10 to override the profits resulting from falling volatility and time decay (the vega and the theta effects).

MANAGING THE RISK ON A SHORT STRADDLE

The major risk involved in selling a straddle is the negative gamma. As discussed in previous sections, this is a ‘wrong-way’ exposure. The higher the negative gamma, the more quickly

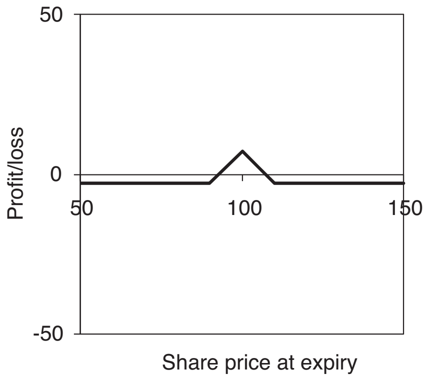

Figure 17.7 Lowering the risk on a short straddle trade

the delta neutrality will break down, and the faster the strategy will lose money as the spot price of the underlying fluctuates.

One way to reduce the risk is to sell a straddle and also buy out-of-the-money call and put options on the same underlying. This provides some protection against larger movements in the price of the underlying.

Figure 17.7 shows the expiry payoff profile of the short straddle struck at \$100, but this time combined with a long call struck at \$110 and a long put struck at \$90. The straddle is sold for a premium of \$11.75. The premium paid on the long call and put is \$4.5. Therefore, the net premium received on the whole combination is \$7.25, which is also the maximum profit that can be achieved. The maximum loss is \$2.75.

The effect of buying the out-of-the-money call and put is to limit the potential loss. It also reduces the negative gamma, which from a trading perspective means that the trade will stay roughly delta neutral for fairly large swings in the spot price of the underlying. The problem is that it costs premium to buy the two options, which reduces the available profit. (The combined strategy is sometimes called an **iron butterfly**.)

Dynamic hedging

Another way to try to combat the negative gamma on a short straddle is to monitor the position and manage the risk dynamically. For example, if the spot price of the underlying keeps rising, the short straddle will become delta negative and the losses on the position will accelerate, as Figure 17.5 illustrates.

This problem can be tackled by 'buying delta', e.g. by buying some of the underlying. This helps to neutralize losses arising from further increases in the share price. There is, however, a potential difficulty. If the spot price subsequently *falls back again*, the shares that were purchased to achieve delta neutrality will no longer be required. They would have to be sold for less than the purchase price, realizing a loss.

The same thing would happen in reverse, if the underlying share price fell. The short straddle would become delta positive, like a long position in the share. One way to combat this is to short the underlying, but if the spot price subsequently increased then the short position would have to be closed out at a loss.

Chasing the Delta

As discussed in Chapter 15, chasing the delta in this way can be extremely costly. The lesson is that a trader who sells a straddle has to be confident about the volatility forecast. If the underlying trades in a narrow range then the risks on the trade can be managed at reasonable cost, and overall a profit will be realized. However, if the underlying turns out to be much more volatile than forecast, then the losses realized by managing the delta exposure will exceed the premium charged at the outset.

SHORT STRANGLE

The losses on the short straddle are potentially unlimited, and it is very exposed to directional changes in the spot price of the underlying. One way to lower this risk is to construct a **short strangle**. This consists of selling a call and a put on the same underlying and with the same expiry date, but this time struck out-of-the-money.

Figure 17.8 shows the expiry payoff profile for a short strangle with the call and put strikes set at $110 and $90 respectively. It contrasts with the expiry payoff profile for the short straddle shown in Figure 17.2.

Compared to the short straddle, the advantage is that the price of the underlying has to move by a significant extent before the initial premium is lost. The disadvantage with the short strangle is that the premium income earned is much reduced because the two options are struck out-of-the-money. In this particular example the premium received at the outset is about $4.5 compared to $11.75 with the short straddle in Figure 17.2.

NEW WAYS OF TRADING VOLATILITY

It has now become possible to trade volatility through a range of innovative new products such as the **volatility swap**. This is a type of forward contract in which the payoff depends on the difference between a fixed volatility level on a given asset and what the actual realized volatility on the asset turns out to be over the life of the contract.

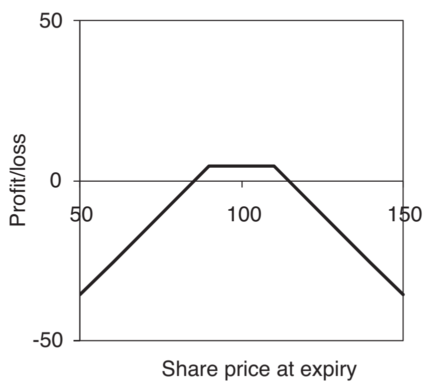

Figure 17.8 Expiry payoff profile for short strangle

It is also now possible to trade volatility futures and options on the Chicago Board Options Exchange (CBOE).

The CBOE VIX

The CBOE® Volatility Index (VIX) was introduced in 1993. It measures the volatility expectations built into S&P 500 index options with 30 days to expiry. It uses an explicit formula that derives market expectations of volatility on the S&P 500 directly, rather than extracting or 'backing out' an implied volatility assumption using an option pricing model. The VIX is calculated in real time throughout the trading day.

The VIX is used as the basis for a range of exchange-traded futures and option products that allow traders to bet on or hedge against changes in volatility levels. The VIX is sometimes called the 'investor fear gauge' because it tends to rise during periods of increased anxiety in the financial markets and of steep market falls.

CALENDAR OR TIME SPREAD

The final spread trade explored in this chapter is a **calendar** or time spread. Essentially it is designed to exploit the fact that a shorter-dated option has a faster rate of time value decay – a higher absolute theta value – compared to a longer-dated option on the same underlying.

Figure 17.9 shows the time value decay for a three-month and a one-month call on the same underlying. Both options are struck at-the-money. The options have been revalued over a period of time, assuming that all the other inputs to the pricing model remain constant, and that only time elapses. The graph shows that, under this assumption, the shorter-dated call loses time value more quickly than the longer-dated option.

A calendar spread could be assembled to exploit this fact. It would consist of shorting the one-month call and buying the three-month call. As time elapses, other things being equal, the shorter-dated option will tend to lose value more quickly than the longer-dated option. This would generate a trading profit, because to close out the overall position the short call has to be repurchased and the long call sold back into the market. The more quickly the short call loses value the better, because it can be repurchased at a cheaper price.

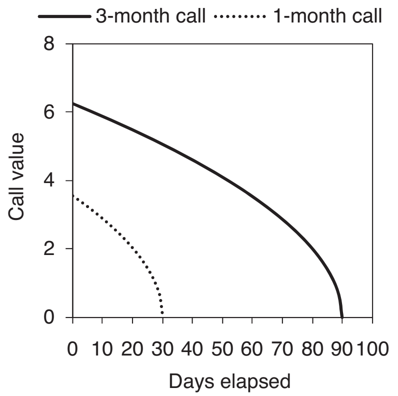

Figure 17.9 Time value decay for calls with different expiry dates

Theta values

At the outset (with zero days elapsed) the theta value on a long position in the three-month call in Figure 17.9 is about −\$0.04. This means that if one day elapses the loss through time value decay is about four cents per share, all other inputs to the pricing model remaining constant.

However the theta value on a short position in the one-month call is about \$0.06. This means that if one day elapses (other inputs to the pricing remaining constant) the gain through time value decay on this option is greater at about six cents per share. As further days elapse the potential profit from the calendar spread trade can accelerate. This is because the rate of time decay is not linear.

Risks with the calendar spread

The risk is that all the other factors that determine the value of the options may *not* remain constant. In the example the two calls were struck at-the-money in relation to the spot price at the outset, and the deltas would therefore net out – the delta of the short call is negative and that of the long call is positive.

As a result, for small directional movements in the underlying share price, the net profit and loss on the overall position will be close to zero: any losses on one option will be compensated for by gains on the other. However the short one-month call has **higher gamma** than the long three-month call. This means that the delta-neutrality will break down for larger movements in the price of the underlying. If the share price rises sharply, for example, the losses on the short call will exceed the profits on the long call option.

CHAPTER SUMMARY

A chooser is a nonstandard option in which the buyer decides after a set period of time whether it is to be a call or a put. It is similar in its payoff to a straddle. A short straddle combines a short put and call on the same underlying with the same strike and expiry date. It is commonly used to take views on volatility. It is short vega. This means that if the volatility assumptions used to price options on the underlying fall then (other things being equal) the call and the put can be repurchased at a cheaper price. This would realize a trading profit.

The problem with a short straddle is that it can be highly risky. If the price of the underlying asset increases or decreases sharply it can generate substantial losses. It is a negative gamma trade, which means that the losses can actually start to accelerate. One way to limit the potential losses is to buy an out-of-the-money call and put on the same underlying. Another possibility is to sell a strangle rather than a straddle. This is similar to a short straddle, but the strikes of the options are set out-of-the-money. It is less exposed to directional movements in the price of the underlying. The snag with both these approaches is that the potential profits are reduced.

It is now possible to bet on, or hedge against, changes in the volatility of a share or an equity index by using volatility swaps or exchange-traded volatility futures and options. The contracts on the CBOE based on the VIX are particularly important. The VIX measures the volatility expectations built into S&P 500 index options.

A calendar or time spread is a way of taking advantage of the fact that different options tend to lose value over time at different rates. However it can be risky if the market price of the underlying asset moves substantially.

18

Convertible and Exchangeable Bonds

INTRODUCTION

The owner of a standard convertible bond (also known as a 'convert' or a CB) has the right to convert the bond into a predetermined number of shares. The shares are those of the issuer of the bond. Often conversion can take place over most of the life of the bond. The number of shares it can be converted into is called the **conversion ratio**. The current value of those shares is called the **parity** or conversion value of the CB. Some CBs have been issued in which the conversion ratio is adjusted in defined circumstances.

A CB has embedded within it a call option on the underlying shares, which will increase in value if the share price performs well. The option is embedded in the sense that it cannot be split off and traded separately from the convertible bond. It can only be exercised through conversion. When a CB is first issued the investors do not pay a premium to the issuer for the embedded option. Instead, they receive a lower coupon rate (interest rate) than they would on a standard or 'straight' bond from the same issuer, i.e. one without the conversion feature.

A close relative is the **exchangeable bond**. This is exchangeable for shares of a company other than the issuer of the bond. Another variant is the **mandatorily convertible** bond, which must be converted into shares in the future.

INVESTORS IN CONVERTIBLE BONDS

Buyers of CBs tend to fall into two main categories. The first consists of hedge funds and traders searching for arbitrage and relative value opportunities. A later section below describes a classic CB arbitrage trade. The second category are the more traditional or 'outright' investors. These include fund managers who are seeking to generate additional returns by taking an equity exposure but who also wish to ensure that the value of the capital invested in the fund is not placed at undue risk. Convertibles offer clear advantages for the more risk-averse investors.

- **Capital Protection**. There is no obligation to convert a CB. If the share performs badly, a CB can always be retained as a bond, earning a regular coupon (interest payment) and with the par value repayable at maturity. On a day-to-day basis, even if the value of the embedded call has collapsed, a CB will not trade below its value considered purely as a bond. This is sometimes called the **bond floor**.
- **Upside Potential**. On the other hand, if the share performs well then the investor in a CB can convert into a predetermined quantity of shares at a favourable price. In the jargon of the markets, a CB offers upside potential (because of the embedded call option) but also downside protection (because of the bond floor.)
- **Income Enhancement**. The interest paid on the CB may be more than the dividends an investor can earn on the underlying share, at least for a time. If so, the investor will earn an enhanced income until conversion. However, if the embedded call is particularly attractive this may not be the case. Some CBs pay no interest.

- **Ranking**. CBs are higher ranking than straight equity (i.e. ordinary shares or common stock). A company must make interest and principal payments to bond investors before the shareholders are paid anything.
- **Equity-linked Bond**. Professional investors managing fixed income funds can face restrictions on buying shares. The advantage of a CB is that it is structured as a bond although it has an equity-linked return. If the share price rises the convertible will also increase in value.

ISSUERS OF CONVERTIBLE BONDS

Historically CB issuance tended to be dominated by high-growth companies with lower credit ratings, especially in technology sectors. In recent times, however, there have been periods when more highly-rated issuers have been attracted to CB issuance to satisfy an increased appetite among investors for equity-linked bonds.

A lower-rated corporate may find it difficult to sell its shares at an acceptable price. The shares may be perceived by investors as too risky. On the other hand, if it issued straight bonds the coupon (interest) rate demanded by investors may be too high. Or there may no takers at all. If so, the company may find that it can raise capital more effectively by tapping the convertible bond market.

A CB provides investors with a good measure of capital protection in the shape of the bond floor, whilst offering the prospects of attractive returns if the share price performs well. In addition, if the issue is keenly priced, it will attract hedge funds and other traders seeking to construct arbitrage strategies.

Advantages for issuers

In summary, CBs can provide a useful source of capital for companies. There are a number of potential advantages for the issuer compared to selling shares or regular straight bonds.

- **Cheaper Debt**. Because investors have an option to convert into shares, the coupon paid by the issuer of a CB will be less than the company has to pay on a regular or straight bond (i.e. one without the conversion feature). In addition, issuance costs are usually lower and it not normally essential to obtain a credit rating.
- **Selling Equity at a Premium**. The conversion price of a CB is what it would cost an investor to acquire a share by buying and then converting the bond. When a CB is issued the conversion price is set at a premium compared to the price of the share in the cash market. In bull markets the premium can be 50% and more. Investors accept this because they believe there is a good chance that the share price will rise by at least this percentage over the life of the bond. For the issuer this is equivalent to selling shares substantially above the level of the share price at issue (assuming the bonds are converted).
- **Tax Deductibility**. Usually companies can offset interest payments against tax, but not dividends. A corporate that issues a CB can benefit from this so-called **tax shield** until such time as the investors decide to convert and the company issues them with shares.
- **Weaker Credits**. The CB market can help lower credit-rated corporates tap the capital markets. In such cases the share price is often highly volatile which increases the potential from the embedded call and can make the CB attractive to hedge funds.

CB MEASURES OF VALUE

This section considers a CB that was issued some time ago at a par value of \$100, and now has five years remaining until maturity. The details of the bond are as follows.

- Issuer: XYZ Inc.
- Par or nominal value = \$100
- Conversion ratio = 20 (the bond is convertible into 20 XYZ shares)
- Coupon rate = 5% p.a.
- Conversion style: can be converted at any time up to each.

When the CB was first issued, the coupon rate was set below that for a straight bond without the conversion feature. However, investors were prepared to buy the CB because of the value of the embedded call option. At issue, typically somewhere around 75% of the value of a CB consists in bond value and the rest is option value.

Bond value

This example is based on pricing the CB *not at issue*, but some time later with five years remaining to maturity.

Suppose that the required return for straight debt of this credit rating is now 5% p.a., exactly the same as the coupon rate on the CB. This means that the **bond value** of the CB is now exactly par, i.e. \$100. The CB should not trade below its bond value (bond floor) since this represents the value in today's money of the future interest and principal cash flows. Whether the CB is worth *more* than \$100 depends on the current XYZ share price.

Parity or conversion value

Suppose that the spot price of the share is now \$6. This is used to calculate the bond's parity or conversion value.

$$\text{Parity value} = \$6 \times 20 \text{ shares} = \$120$$

Parity measures the equity value of the CB. It measures the current value of the package of shares into which the bond can be converted. Just as a CB should not trade below its bond value, it should not be possible to purchase a CB for less than its parity value, assuming that immediate conversion is permitted.

The reason is the possibility of arbitrage. If a trader could buy the bond for less than \$120 and immediately convert into shares worth \$120 the trader would make a risk-free profit. Market forces should prevent this from happening and a CB should trade for at least its parity value.

CB Parity and Intrinsic Value

CB parity is related to the modern concept of intrinsic value. The CB should not trade below its parity value, in the same way that an American-style call option should not trade below its intrinsic value.

Conversion premium

Does this mean that the CB should *only* trade at its parity value? No, for at least two reasons. Firstly, unlike an investment in the underlying share, the CB offers capital protection in the shape of the bond floor. Secondly, the CB still has five years to maturity and there is a good chance that the share price will increase over that time, which would drive the value of the CB up further. The CB contains an embedded call on 20 XYZ shares with five years to expiry, which has significant time value.

The amount that investors are prepared to pay over and above the parity value of a CB is called **conversion premium** or premium-over-parity. Suppose the XYZ share price is currently \$6 so that the parity value of the CB is \$120. If the CB is trading at a price of (say) \$150 in the market, then its conversion premium is calculated as follows.

$$\text{Conversion premium} = \$150 - \$120 = \$30$$

$$\text{Percentage conversion premium} = \frac{\$30}{\$120} \times 100 = 25\%$$

$$\text{Conversion premium per share} = \frac{\$30}{20 \text{ shares}} = \$1.5$$

If an investor buys the CB for \$150 and immediately converts, then the cost of buying a share is \$7.5 each. This is \$1.5 or 25% more than it would cost to buy the share in the cash market. It also means that the share price has to rise by over 25% before it is profitable for an investor buying the CB for \$150 to convert the bond into shares.

Note that the expression 'conversion premium' does not mean quite the same thing as the modern term 'option premium' though it is related, as shown in the next section.

CONVERSION PREMIUM AND PARITY

Figure 18.1 illustrates the basic relationship between bond value, parity and conversion premium for the CB from the last section for a range of different spot prices of the underlying share. All the other factors that affect the CB value are held constant. The bond value (bond

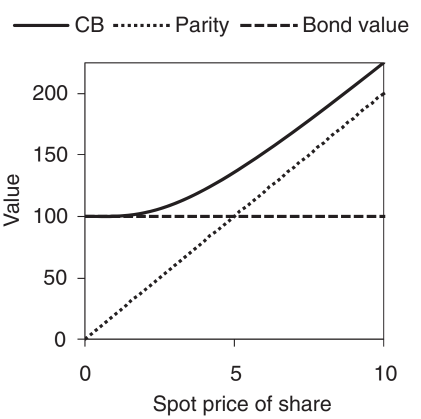

Figure 18.1 Current share price and CB value

floor) is assumed to be $100 and there is now five years to maturity. The CB has been priced assuming a 30% volatility for the underlying share and assuming that the share pays no dividends. Since the CB has a 5% coupon this means that an investor has an income advantage in holding the bond.

In Figure 18.1 parity is shown as a diagonal dotted line. Since the CB is always convertible into exactly 20 shares, the relationship between the share price and parity is perfectly linear. If the share price is very low at (say) $1, then the parity value is $20. At a share price of $10 parity is $200. The bond floor is shown as a horizontal line: the bond value of the CB is taken to be $100 whatever the current share price is. The total CB value is shown as a solid line.

The conversion premium

In Figure 18.1 the difference between the total CB value and the parity value at a given share price is the **conversion premium**. There are two main factors affecting the conversion premium, and which predominates depends on where the share price is trading:

1. **Bond Floor.** At very low share prices the value of the CB reverts to its bond floor. It is extremely unlikely that it will ever be converted and the value of the embedded call option is almost zero. It is deeply out-of-the-money. At this level the conversion premium is largely determined by the fact that the holder of the CB is not obliged to convert and has the comfort of being able to retain the security as a pure bond investment. If the investor owned shares instead, then the value of those shares would be sliding down the diagonal parity line.
2. **Embedded Call.** At very high share prices the value of the CB converges on its parity value. The CB starts to trade like a package of 20 shares since it is almost 100% certain that it will be converted. There is very little uncertainty about the eventual outcome. The embedded call is deeply in-the-money and (as is the case with such options) the time value component is relatively small.

OTHER FACTORS AFFECTING CB VALUE

It is often said that a 'CB is just a bond with an option'. This is a good enough definition when explaining the basic structure, but it can be a little misleading in practice and needs qualification. Firstly, a CB can normally be converted over a period of time and not just at maturity. The pricing methodology has to take into account the fact that it should not trade at less than its parity value, otherwise arbitrage opportunities would be created.

Secondly, when a CB is converted the issuing company normally creates new shares. This has the effect of **diluting** the value of the equity.

Thirdly, the graph in Figure 18.1 assumes that the bond floor is unaffected by changes in the share price. In practice this is unlikely. A CB is issued by a company and is convertible into the shares of the same company. If the share price collapses the bond floor may also drop because of fears that the company may default on its debt. In assessing the value of the CB it is necessary to make some assumptions about the relationship between movements in the share price and the value of the bond floor.

Finally, many CBs incorporate complex early redemption features which affect valuation. For example, the issuer may have the option to 'call' the bond back early at a fixed price if it is trading above a certain trigger level for a period of time. By putting out a call notice the issuer can force issuers to convert. It can then sell new CBs at a conversion price set above the current share price level. Some CBs include a number of different call features.

Pricing Exchangeable Bonds

An exchangeable bond is exchangeable for shares of a company other than the bond issuer. One advantage compared to a CB is that changes in the credit rating of the issuer are unlikely to be quite so closely correlated with movements in the price of the underlying shares, since the shares are those of a separate organization.

CONVERTIBLE ARBITRAGE

Traders and hedge funds often see convertible bonds as a cheap way of 'buying volatility'. This happens when the implied volatility on the embedded call option is relatively low. (Chapter 14 introduced implied volatility.)

One way to exploit this kind of situation is to buy the CB and sell exchange-traded or over-the-counter options on the same underlying, assuming that these contracts are trading at higher implied volatility levels. In effect this involves simultaneously buying 'cheap' options and selling more expensive options on the same underlying.

This is not a perfect arbitrage, because the value of the CB is affected by factors other than movements in the underlying share price. For example, if the credit rating of the issuer is cut this will lower the bond floor and hence the overall CB value.

Classic CB arbitrage

The 'classic' convertible arbitrage trade involves buying a CB and shorting the underlying in the correct proportions. Take the example of the CB from the previous sections, which is convertible into 20 XYZ shares.

Suppose the underlying share is trading at \$5 and the CB has a delta of 0.75. Then (in response to small movements in the underlying share price) the changes in the value of the CB will be similar to that on a long position in 15 underlying shares (0.75×20). In the classic arbitrage trade this is then matched by shorting 15 XYZ shares.

Buying a CB involves acquiring an embedded call on the underlying. This is a positive delta position. Shorting the underlying share balances this out because it is a negative delta position. This means that (for small movements in the share price) the profits and losses will cancel out. The overall position is delta neutral.

CONVERTIBLE ARBITRAGE EXAMPLE

To continue the arbitrage example introduced in the previous section, suppose that a trader buys \$100 par value of the CB described there. The current XYZ share price is \$5 and the CB delta is 0.75. The trader shorts 15 shares to delta-hedge the CB position.

Suppose further that the underlying share price then rises by \$0.01, without any other changes that will affect the value of the CB. The profit on the CB and the loss on the short stock position will be as follows.

$$\text{Profit on CB} = \$0.01 \times 0.75 \times 20 \text{ shares} = \$0.15$$
$$\text{Loss on shares} = \$0.01 \times -15 \text{ shares} = -\$0.15$$

However if the share price increases sharply the profits on the CB will exceed the losses on the short stock position, because the CB benefits from the **positive gamma** in the embedded call option. Conversely, because of positive gamma, if the share price falls sharply the losses on the CB will be lower than the gains on the short stock position.

For example, if the share price rises by \$2 then the delta value predicts a rise of \$30 in the CB value.

$$\text{Profit on CB predicted by delta} = \$2 \times 0.75 \times 20 \text{ shares} = \$30$$

To keep matters simple, the CB is priced as a combination of a straight bond worth \$100 and a call option on 20 XYZ shares. Volatility is assumed to be 30% p.a. This method suggests that a \$2 rise in the underlying share price will actually generate an increase in the CB value of about \$33, and not \$30. The 'extra' \$3 is produced by the gamma effect. Meantime the loss on the 15 shares shorted in the delta hedge (for a \$2 rise in the share price) will be only \$30.

PROFITS AND RISKS WITH THE CB ARBITRAGE TRADE

Figure 18.2 shows the theoretical profits on the arbitrage trade for different levels of the underlying share price, assuming all other inputs to the pricing of the CB remain constant. It shows the profits and losses on the CB, on the short position in the underlying shares, and then on the combined position, i.e. on the CB arbitrage strategy.

The 'classic' CB arbitrage trade is positive gamma, as shown by the convex curve for the combined position in Figure 18.2. The profits tend to accelerate for larger swings in the spot price of the underlying. The strategy is also positive vega. This means that it will tend to make a profit if volatility expectations on the underlying rise in the market. This will increase the value of the embedded call in the CB.

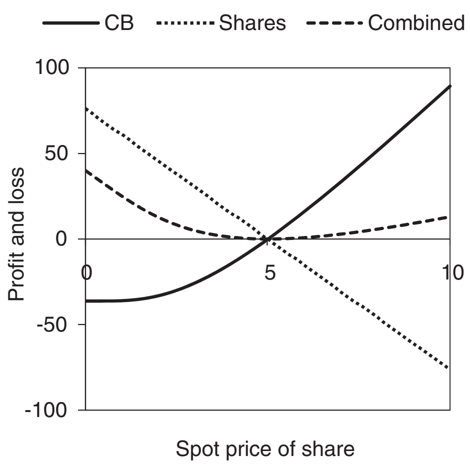

Figure 18.2 Convertible arbitrage strategy

Risks with CB arbitrage trade

Despite its name, the classic CB arbitrage trade as normally constructed is not actually a pure arbitrage position. This is because a number of risks remain.

- **Vega Risk**. If volatility expectations fall the CB will tend to lose value. Meantime there may be little effect on the underlying share price, or it may even rise in value, which will generate losses on the short stock position.
- **Credit Risk**. If the issuer's credit rating is cut this will lower the bond value of the CB (although this may also be accompanied by a fall in the underlying share price which would generate profits on the short stock position). This credit risk could be contained by buying protection through a credit default swap, though at a cost.
- **Liquidity Risk**. The CB may be fairly illiquid, which increases transaction costs and also the risk that it may be difficult and expensive to unwind the arbitrage trade in a hurry.
- **Stock Borrowing Risks**. Borrowing the shares to create the short position incurs fees, and it may be difficult to arrange in some circumstances. There is a risk that the stock lender may ask for the shares to be returned.

In addition, the CB may have 'call' features incorporated such that it can be retired early by the issuer. This puts a cap on the profit that can be achieved on a long position in the CB.

MANDATORILY CONVERTIBLES AND EXCHANGEABLES

As the name suggests, a mandatorily convertible (MC) bond is one which the investor *must* convert on a future date. As an example, Deutsche Telekom launched a EUR 2.3 billion MC bond in 2003 to reduce its debt burden.

A **mandatorily exchangeable** (ME) might be issued by a company that has a cross-holding of shares in another business which it definitely wishes to dispose of at some future date. In effect the bond is a deferred or forward sale of the shares but with the cash proceeds received up-front. There are many reasons why the company might wish to dispose of the shares in this way rather than by simply selling them in a cash market transaction.

- It may be more tax efficient.
- The market impact may be lower – announcing a sale of a large block of shares could seriously affect the market price. This would be particularly painful if the company intended to retain some of its holding.
- There may be legal or regulatory restrictions on selling the shares until some period of time has elapsed.

Simple example of ME bond

A very simple example may help to explain the basic idea. A more detailed (and realistic) example is given in the next section. Suppose that a company owns a block of shares it wishes to dispose of in one year's time. The current share price is \$100, the annual dividend is \$1 per share and the one-year interest rate is 5% p.a. The one-year fair forward price, established using the cash-and-carry method explained in Chapter 2, is therefore \$104.

$$\text{Forward price of share} = \$100 + \$5 - \$1 = \$104$$

The company could go to a dealer and agree to sell the shares forward in an OTC transaction. If it contracts the forward deal at $104 per share then it could borrow money today against the future cash flow guaranteed by this transaction. It is due to receive $104 per share in one year's time so, at an interest rate of 5% p.a., it could borrow just over $99 per share today.

Alternatively, rather than agree the forward, the company might get a better deal by selling a mandatorily exchangeable bond to investors through the public markets. The terms of the bond might be as follows:

- Bond issue price = $100
- Maturity = one year
- Exchange ratio: each bond is mandatorily exchangeable at maturity into one share
- Coupon rate = 0% (i.e. the bond pays no interest).

In this structure, investors buy a bond for $100 and one year later they receive (without any choice) one share per bond. In effect, the company is selling the shares to the bond investors in a year's time but receiving the proceeds up-front. The advantage is that it is receiving $100 per share up-front rather than the $99 that could be borrowed against a forward sale of the shares.

In practice MC and ME bonds can be constructed such that investors have some protection against a fall in the share price. Alternatively, there is no capital protection as such, but investors receive an attractive coupon in compensation for the requirement to exchange the bond for shares. An example is explored in the next section.

STRUCTURING A MANDATORILY EXCHANGEABLE (ME) BOND

The advantage of these deals is that they can be packaged in different ways to make them more attractive to investors.

One technique used by investment banks is to issue an ME bond with a coupon rate (fixed rate of interest) that is very attractive to investors. In return, investors are obliged to exchange the bond for shares at maturity, using an exchange ratio formula that can produce a lower rate of participation in any rise in the share price compared to purchasing the actual shares in the first instance.

For example, a deal might be structured along the following lines. The underlying share in this example is XYZ. It is currently trading at $100 and it pays no dividends.

- Bond issue price = $100
- Maturity = three years. At this point the bond must be exchanged for XYZ shares
- Exchange ratio: If the XYZ share price is below $100 at maturity the bond investor receives one share per bond. At share prices between $100 and $125 the investor receives a quantity of shares worth $100
- At share prices above $125 the bond investor receives 0.8 shares per bond
- Bond coupon rate = 5% p.a.

Capital gains and losses on the ME bond

The solid line in Figure 18.3 shows the capital gain or loss an investor would make on this ME bond at maturity for a range of different possible share prices. The assumption is that the investor has purchased a bond for $100 when it was issued. For comparision, the dotted

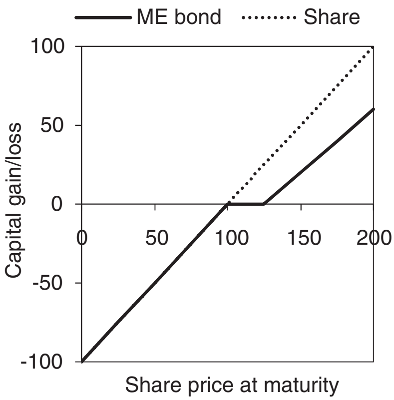

Figure 18.3 Capital gain/loss on ME bond at maturity

line shows the capital gains and losses the investor would have achieved if instead the $100 purchase price was used to buy one XYZ share in the first instance.

A few examples will help to explain the ME bond values in the graph. Recall that the bond purchase price is $100. These examples take a number of different possible values for the share price at the maturity of the ME bond.

- **Share Price** = $**75**. The investor receives one share worth $75 and so the capital loss on the bond is $25.
- **Share Price** = $**100**. The investor receives one share worth $100. The capital gain on the bond is zero.
- **Share Price** = $**100 to** $**125**. The investor receives shares worth $100. The capital gain on the bond is zero.
- **Share Price** = $**150**. The investor receives 0.8 shares worth $120. The capital gain on the bond is $20. This is $30 less than the gain if the investor had purchased one XYZ share for $100 in the first instance.

At share prices higher than $125, the investor in the ME bond begins to participate in further increases in the share price, but to a lesser extent than if he or she had bought shares in the first instance. Also, the bond does not offer the kind of capital protection afforded by a traditional convertible or exchangeable bond.

However it does pay a high coupon rate of 5% p.a. while the underlying share pays no dividends. The investor has the benefit of this income advantage for three years and then the bond has to be exchanged for shares. In a flat share market with little opportunities for capital growth this may be a major plus point. The coupon income also provides some offset against a possible fall in the value of the shares over the three years.

CHAPTER SUMMARY

A convertible bond (CB) can be converted into a predetermined number of shares of the issuer, at the decision of the bond owner. The number of shares acquired is determined by the conversion ratio. The parity value of a CB is its value considered as a package of shares, i.e. the conversion ratio times the current share price. The bond floor is its value considered purely as a bond. A CB should not trade below its bond floor or its parity value, assuming that immediate conversion is possible. Its value over and above parity is called conversion premium.

Conversion premium is affected by the value of the call option that is embedded in a CB. At a low share price it is unlikely that the CB will be converted and it trades close to its bond floor. Conversion premium is high. At a high share price conversion is likely and the CB will trade close to its parity value. Conversion premium is low.

CBs are bought by investors who wish to profit from increases in the share price but who do not wish to suffer excessive losses if it falls. They are also bought by hedge funds and others as a means of acquiring relatively cheap options. The classic convertible arbitrage trade involves buying a CB and shorting the underlying share. It benefits from rising volatility. In practice, valuing a CB can be complex because it often incorporates ‘call’ features that allow the issuer to retire the bond before maturity.

An exchangeable bond is issued by one organization and is exchangeable for shares in another company. They are sometimes issued by an organization that has acquired an equity stake in another business; rather than sell the shares outright, it raises relatively cheap debt by selling bonds that are exchangeable for those shares.

An investor who buys a mandatory convertible or exchangeable bond is obliged to return the bond and acquire shares at some future date. The bond may be structured such that the investor receives a high coupon or has some level of capital protection.

19

Structured Securities

INTRODUCTION

One of the strengths of derivatives is that they can be combined in many ways to create new risk management solutions. Similarly, banks and securities houses can use derivatives to create new families of investments aimed at the institutional and retail markets.

Products can be developed with a wide range of risk and return characteristics, designed to appeal to different categories of investors in different market conditions. The choice is no longer limited to buying bonds or shares or placing money in a deposit account. Derivative instruments can create securities whose returns depend on a wide range of variables, including currency exchange rates, stock market indices, default rates on corporate debt, commodity prices – even electricity prices or the occurrence of natural disasters such as earthquakes.

Attitudes to Risk

Some structured products are aimed at the more cautious or risk-averse investor. They incorporate features that protect at least some percentage of the investor's initial capital. Others actually increase the level of risk, for those who wish to achieve potentially higher returns. Chapter 1 discusses some of the potential pitfalls.

Derivatives also allow financial institutions and corporations to 'package up' and sell off risky positions to investors who are prepared to take on those risks for a suitable return.

Chapter 18 gives an example of the technique. A company that owns a cross-holding in another firm's equity can issue an exchangeable bond. The company benefits from cheaper borrowing costs and (assuming exchange takes place) will never have to pay back the principal borrowed. The bond could be structured as a mandatorily exchangeable, such that the shares are *definitely* sold off on a future date at a fixed price but with the proceeds from the sale received up-front.

There are many ways in which derivatives can be used to create structured securities, and only a few examples can be explored here. The first sections in this chapter examine a very typical structure, an equity-linked note with capital protection. They explore a number of different ways in which the product can be constructed to appeal to different investor groups, and consider the components that are used in its manufacture.

The final sections describe structured securities whose returns are linked to the level of default on a portfolio of loans or bonds. Until it was affected by the 'credit crunch' this was one of the largest growth areas in finance.

CAPITAL PROTECTION EQUITY-LINKED NOTES

A typical equity-linked note (ELN) offers investors capital protection plus some level of participation in the rise in the value of a portfolio or basket of underlying shares. When sold into the retail market, the return on these products is usually linked to the level of a well-known stock market index such as the S&P 500 in the US or the FT-SE 100 in the UK. An index like this simply tracks the change in the value of a typical portfolio of shares.

The notes can also be given a 'theme' chosen to be attractive to investors at a particular moment in time. For example, the payoff might depend on the value of an index of smaller company shares or of technology stocks.

This section looks at how the structuring desk in a bank can assemble and manage the risks on a typical ELN. The structure is an ELN based on an underlying portfolio of US stocks with a current market value of $50 million. The notes will be sold to investors for a total of $50 million and will mature in two years. They will be redeemed in cash at maturity, i.e. investors will be paid the maturity value in dollars and will not receive any actual shares.

ELN maturity value

The maturity value of the notes will be calculated as follows:

$$\text{Maturity value} = (\text{Principal invested} \times \text{Capital protection level}) + (\text{Principal invested} \times \text{Basket appreciation level} \times \text{Participation rate})$$

For example, suppose the notes are issued with 100% capital protection and 100% participation in any increase in the value of the basket of shares over two years. If at maturity the basket of shares is worth $40 million, then the investors collectively get back the $50 million they invested initially, and suffer no loss of capital. But if the basket has risen in value by (say) 50%, then the investors are collectively paid a total of $75 million at maturity.

$$\text{Maturity value} = (\$50 \text{ million} \times 100\%) + (\$50 \text{ million} \times 50\% \times 100\%) = \$75 \text{ million}$$

Capital guarantee

How can the structuring desk assemble and hedge these notes? The first step is to guarantee the investors' capital. The strategy here is to take a proportion of the $50 million raised by selling the notes and invest the money for two years, so that, with interest, it will grow to a value of exactly $50 million at maturity.

Suppose a suitable fixed rate investment is found that pays 5.6% p.a. In that case if $44.84 million is placed in this investment it will be worth $50 million at maturity in two years. This can be used to guarantee the $50 million principal on the structured notes. (Appendix A explains compound interest calculations of this kind.)

Generating the participation

The next step for the structuring desk is to find a way of paying the investors a return based on any appreciation in the value of the portfolio. Clearly it is not possible to do this by buying the *actual shares* in the portfolio since most of the money collected from the investors has to be used to guarantee the capital repayment.

Instead the strategy is to buy a European call option that pays off according to the value of the basket of shares in two years' time, the maturity of the structured notes. The strike is set at-the-money at $50 million. Suppose the portfolio at maturity is worth $75 million, a rise of 50% from the starting value. Assuming 100% capital protection and 100% participation, the investors would have to be paid $75 million at maturity. However, this is covered. There is

$50 million from the maturing deposit and the intrinsic value of the call option would be $25 million.

$$\text{Call value} = \$75 \text{ million} - \$50 \text{ million} = \$25 \text{ million}$$

The final step then is to buy a two-year at-the-money European call on the basket of shares. Suppose that this would cost $8.6 million. Then it is quite clear that the structuring desk cannot offer the investors 100% capital protection *and* 100% participation in any rise in the value of the portfolio. $50 million was collected from investors and $44.84 million was placed on deposit, which leaves only $5.16 million to buy an option contract.

Calculating the participation rate

If the investors demand the full capital guarantee, the amount spent on the call option has to be reduced. In fact the premium the structuring desk is able to pay determines the participation rate it can offer. A premium of $8.6 million buys 100% participation; therefore the budget can only afford a maximum participation rate of 60%.

$$\text{Maximum participation rate} = \frac{\$5.16 \text{ million}}{\$8.6 \text{ million}} = 60\%$$

EXPIRY VALUE OF 100% CAPITAL PROTECTION NOTES

The solid line in Figure 19.1 shows the potential capital gains on the ELNs at maturity, on the basis that they are offered with 100% capital protection and a 60% participation rate.

Some examples will help to explain the values in Figure 19.1. Suppose that the underlying basket of shares at maturity is worth $40 million, $50 million or $60 million.

- **Basket Value** = $**40 million**. The notes offer 100% capital guarantee, so investors get back their original $50 million and suffer no capital loss, even though the value of the underlying shares has fallen sharply.
- **Basket Value** = $**50 million**. Again the investors are repaid their original $50 million and suffer no capital loss.

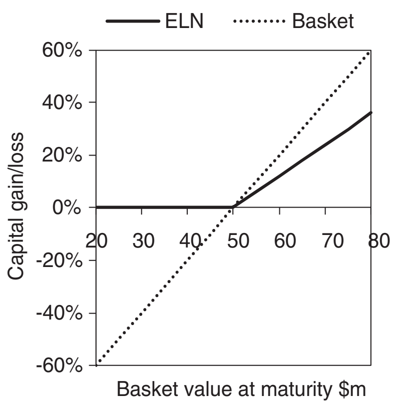

Figure 19.1 Capital gains/losses on 100% capital guarantee note

- **Basket Value = $60 million**. Investors are repaid their $50 million capital which is guaranteed. However on top of this the basket of shares has risen in value by 20%, the participation rate is 60%, so they are also paid an additional $50 million × 20% × 60% = $6 million. The capital gain for the investors is 60% × 20% = 12%.

The dotted line in Figure 19.1 shows the percentage rise in the underlying basket of shares. If the basket at maturity is worth (say) $80 million then an investor who had bought the underlying shares in the first instance would have achieved a capital gain of 60%. An investor in the ELNs would have made 60% of this, i.e. 36%.

On the other hand, if the basket is only worth $20 million at maturity then an investor in the shares would have *lost* 60% of their capital whilst a purchaser of the notes would have lost none. Note that this analysis only considers capital gains and losses; the ELNs do not pay any dividends or interest. Potential investors could buy the underlying shares and earn dividend income, or deposit the cash with a bank and earn interest.

100% PARTICIPATION EQUITY-LINKED NOTES

Some investors prefer to have a lower level of capital protection but a higher degree of participation in any increase in the value of the underlying index or portfolio of shares.

Suppose this time the structuring desk decides to offer a 100% participation rate. A previous section said that this would require an expenditure of $8.6 million to purchase a call option. This establishes how much remains from the original $50 million collected from the investors in the ELNs to place on deposit for two years.

Amount remaining to invest = $50 million − $8.6 million = $41.4 million

If this is invested for two years at 5.6% p.a. it will produce a total of approximately $46.2 million at maturity.

This shows that the structuring desk can only afford to guarantee a repayment of $46.2 million to the investors at maturity, which is roughly 92% of the initial capital they provided. This is on the assumption that the investors are also offered 100% participation in any rise in the value of the basket of shares. Figure 19.2 shows the potential capital gains and

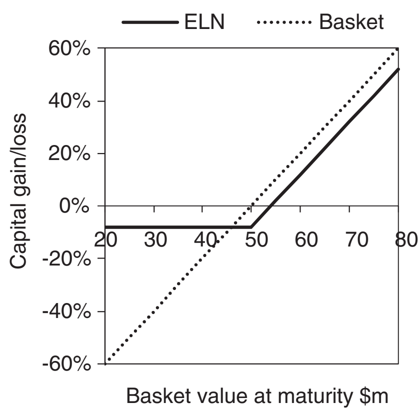

Figure 19.2 Capital gains/losses on 100% participation note

losses at maturity for ELNs structured in this way (92% capital protection, 100% participation).

Features of the 100% participation notes

With these ELNs, if the underlying shares are worth \$50 million at maturity in two years investors are repaid 92% of their capital (a loss of 8%). If an investor had bought the actual shares the capital loss would have been zero. On the other hand, the maximum loss on the notes is 8% while 100% could potentially be lost on the shares.

If the shares are worth *more* than \$50 million at maturity, the advantage of the 100% participation rate becomes apparent. For example, if the shares are worth \$80 million these notes produce a capital gain of 52%. This compares favourably with a 36% gain on the 60% participation (100% capital protection) notes. However it compares *unfavourably* with a direct investment in the shares, which would have returned a 60% capital gain.

Different Classes of ELNs

One further possibility is to offer different classes of notes aimed at different purchasers, some with higher capital protection aimed at the more risk-averse, and also 100% participation notes aimed that those who are prepared to take a little more risk for potentially higher rewards.

Note that the securities structured so far are similar to exchangeable bonds. There is a level of capital protection plus an equity-linked return. The main difference is that they are settled in cash at maturity rather than through the physical delivery of shares.

CAPPED PARTICIPATION EQUITY-LINKED NOTES

Continuing the example from previous sections, it *is* possible to offer investors 100% capital protection and also 100% participation in any rise in the value of the basket of shares, but at the cost of capping the profits on the ELNs.

How can the structuring desk establish the level of the cap? The strategy involves selling an out-of-the money call on the basket and receiving premium. This increases the amount of money available to buy the at-the-money call on the basket. However the profits on the equity-linked notes must be capped at the strike of the call that is sold.

It is easy to work out how much money has to be raised from selling the out-of-the-money call.

Deposit to offer 100% capital protection = \$44.84 million

Cost of long call to offer 100% participation = \$8.6 million

Unfortunately only \$50 million is collected from the ELN investors, so this leaves a shortfall of \$3.44 million. Suppose that the structuring desk contacts a dealer and agrees to write a call on the basket of shares struck at a level of \$67.5 million, which raises exactly \$3.44 million. The strike is 35% above the spot value of the basket.

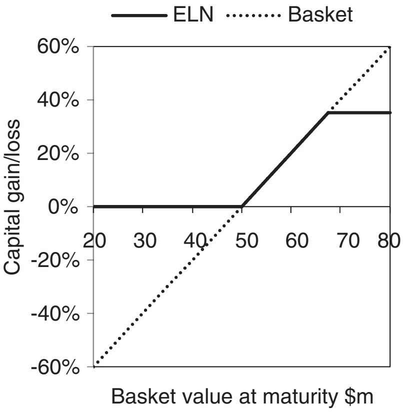

Figure 19.3 Capital gains/losses on capped ELNs

Structure of the capped ELNs

The structuring desk *can* promise 100% capital protection and 100% participation in any rise in the basket, but the capital gains on the notes must be limited to $17.5 million. The desk buys a call on the basket struck at $50 million. However, any gains on the underlying shares beyond a value of $67.5 million will have to be paid over to the dealer who bought the $67.5 million strike call, so they are not available to pay out to the ELN investors.

Figure 19.3 compares the capital gains and losses on the capped equity-linked notes to what investors in the notes would have achieved if they had invested the money in the actual underlying shares in the first instance.

Some examples will help to explain the values in Figure 19.3. Suppose that the underlying basket of shares at maturity is worth $40 million, $60 million or $80 million.

- **Basket Value = $40 million**. The notes offer 100% capital guarantee, so investors get back their original $50 million and suffer no capital loss, even though the value of the underlying shares has fallen sharply.
- **Basket Value = $60 million**. Investors are repaid their $50 million capital. However on top of this the basket of shares has risen in value by 20%, the participation rate is 100%, so they are also paid an additional $50 million x 20% = $10 million. The capital gain for the investors is 20%, as it would have been if they had bought the underlying shares in the first instance.
- **Basket Value = $80 million**. Investors are repaid their $50 million capital. The basket has risen in value by 60%. However the capital gain on the ELNs is capped at $17.5, million which is 35% of the original $50 million paid for the notes by the investors. The total amount paid to investors at maturity is $67.5 million.

The capital gain on the notes is capped here at 35%, but the potential gains if the actual shares had been purchased by the investors are unlimited. Also, the shares would pay dividends which can be reinvested, whereas the notes pay no interest. They *could* be structured to include interest payments, but some other feature would have to be adjusted. For example, the capital protection level could be reduced, or the level of the cap lowered.

AVERAGE PRICE NOTES

One concern investors might have about purchasing the ELNs is that the underlying basket of shares could perform well for most of the two years until the notes mature, and then suffer a serious collapse towards the end. This sort of problem is illustrated in Figure 19.4.

In Figure 19.4 the underlying portfolio of shares is worth $50 million at the outset and, with some ups and downs, is trading comfortably above that level with only a few months to the maturity of the notes. However, it then suffers a slump. In all of the versions of the ELNs considered so far in this chapter, the investors would not benefit from those interim price rises. The payout is based solely on the value of the basket of shares at maturity.

One way to tackle this problem is to use an **average price** or Asiatic call option when assembling the notes. The value of a fixed strike average price call option at expiry is zero, or the difference between the average price of the underlying and the strike, whichever is the greater.

These contracts are designed to help with the sort of concerns investors may have about the equity-linked notes, since the payout would not be based on the value of the basket at a specific moment in time – the expiry date – but its average value over a defined period. This could be the three- or the six-month period leading up to expiry, or even the whole life of the option. The averaging can be based on daily or weekly or monthly price changes.

Advantages for the Structuring Desk

Average price or Asiatic options have another advantage of great practical importance to structurers assembling products such as equity-linked notes. All other things being equal, an average price option tends to be *cheaper* than a standard vanilla option.

Cost of average price options

The reason why average price options are normally cheaper than standard contracts relates to volatility. The averaging process has the effect of smoothing out volatility.

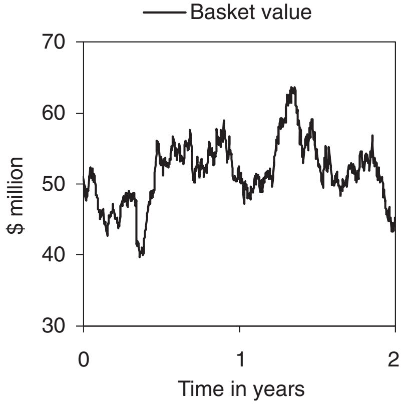

Figure 19.4 Potential price path for the basket of shares over two years

To put it another way, the average value of an asset over a period of time tends to be relatively stable, more so than the spot price over the same period. (This assumes that the movements follow a random path, so that price rises and falls tend to cancel out to some extent.) The more frequently the averaging process is carried out, the better the smoothing effect. All other things being equal, an average price option with daily averaging is cheaper than one with weekly averaging.

Previous sections showed that to structure the ELNs with 100% capital protection the structuring desk has to deposit $44.84 million. Using a standard call option, it needs to pay $8.6 million in premium to offer a 100% participation rate. The reason for adjusting the notes in various ways – e.g. lowering the participation rate or capping the profits – is that there is not enough cash available to do both. However, with the same values used to price the standard call, the cost of buying an average price option could actually come in within budget.

The structuring desk could offer a 100% capital guarantee plus 100% participation in any increase in the *average value* of the basket.

LOCKING IN INTERIM GAINS: CLIQUET OPTIONS

Average rate options are useful but they are not helpful if the shares perform well and then very badly indeed for a sustained period of time leading up to maturity. The chances are that the average price would be below the strike.

One solution to this problem, although it is likely to be expensive, is to use a **cliquet** or ratchet option when assembling the ELNs. A cliquet is a product that locks in interim gains at set time periods, which cannot subsequently be lost. It consists of a standard option starting now plus a series of options that start in the future.

Using a cliquet option

In this case the structuring desk could assemble the ELNs by buying a cliquet consisting of two elements:

- **Spot-start Call**. A one-year European call starting spot with a strike at the current spot value of the basket, i.e. $50 million. This is a standard call option.
- **Forward-start Call**. A one-year European call, starting in one year, with the strike set at the spot value of the basket at that point in time.

To help explain how the cliquet works, Figure 19.5 shows one potential price path for the basket of shares over the next two years.

In Figure 19.5 the value of the basket of shares starts at $50 million. At the end of one year it is worth approximately $55 million. The first option in the cliquet, the spot start call, will expire at that point and will be worth $5 million in intrinsic value. This cannot be lost.

Now the strike for the *second* option in the cliquet, the forward start call, will be set at $55 million. Figure 19.5 assumes that the basket of shares is worth less than $55 million at the expiry of that second option, at the end of two years. So the second option in the cliquet will expire worthless. If the basket at expiry was worth *more* than $55 million then gains would be achieved in addition to the $5 million already locked in at the end of one year.

The problem with the cliquet is the cost of the premium. It actually consists of *two* call options, each with one year to maturity, one starting spot and the other starting in a year's time. This is more expensive than a standard two-year call option because it provides additional

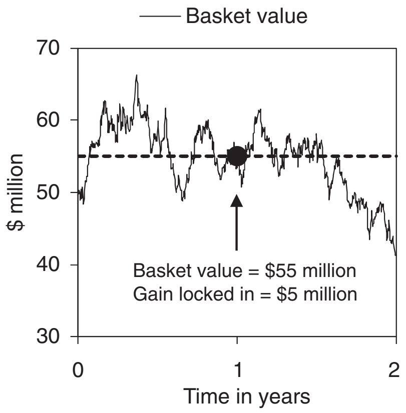

Figure 19.5 Possible price path for the basket and locked-in gains

flexibility. The result is that if the cliquet is used, the capital protection level on the notes would have to be lowered, or the participation rate cut, or the returns capped.

SECURITIZATION AND CDOs

The final examples in this chapter explore structured bonds whose returns are linked to the level of default on a pool of debt assets.

Generally, securitization is the process by which bonds are created from future cash flow streams. Mortgage-backed securities (MBS) are based on a pool of mortgage loans. The bonds may be simple **pass-through** structures, which means that the cash flows from the loans are passed through on a pro-rata basis to make the principal and interest payments to the bondholders. Or different classes of bonds may be created with different characteristics. For example, IO (interest only) bonds are paid from the interest cash flows from the mortgage pool while PO (principal only) bonds are paid from the principal redemption cash flows.

A **collateralized debt obligation** (CDO) is a bond that is sold to investors via a Special Purpose Vehicle (SPV) set up by a financial institution such as an investment bank which acts as the deal structurer. The SPV is used to assemble a pool of loans or debt securities and to sell securities to investors backed by the cash flows generated by the asset pool.

Three or more different classes or **tranches** of securities are sold which have different risk and return characteristics. The least secure class (known as the equity tranche) takes the first loss if any of the loans or debt securities in the asset pool suffer from default. The middle or mezzanine tranches suffer the next losses. The senior tranche is the most secure and is designed to be safe unless the pool of assets suffers severe losses.

CLOs and CBOs

Depending on the nature of the underlying assets in the pool, a CDO may be called a Collateralized Loan Obligation (CLO) or a Collateralized Bond Obligation (CBO).

THE BASIC CDO STRUCTURE

The basic CDO structure is illustrated in Figure 19.6, although in practice there are many variations. The SPV is a tax-exempt trust or company which raises capital by selling CDOs and which buys the collateral or asset portfolio.

This may be a **static** asset pool, in which case the SPV effectively acts as a conduit to collect the cash flows and make the agreed payments to the CDO holders. In other cases the portfolio is **actively managed** within set guidelines, in which case an asset manager is appointed to make investment decisions.

The interest rate and currency risks on the portfolio are managed using derivative products. The **trustees** have a safekeeping duty to ensure that the assets are protected and maintained for the benefit of the CDO investors.

Credit enhancement

The process of creating different tranches of CDOs is a **credit enhancement** feature. It means that the senior tranche can obtain a high credit rating because the more junior tranches suffer the first losses and are also paid after the senior tranche.

The system of payments in a CDO structure is sometimes called the cash flow **waterfall**. The tranches are paid in sequence out of the cash flows from the collateral, from the highest to the lowest ranking, with the equity tranche paid last. Other credit enhancement techniques include **over-collateralization** (excess assets are added to the collateral pool) and obtaining guarantees from a third party organization such as an insurance company to make good any shortfalls on the cash flows from the collateral.

The senior tranche

The senior tranche in a CDO structure is the largest. The bonds pay the lowest coupons, but they are also intended to have the lowest risk to investors. They are generally intended to be attractive to institutional investors such as insurance companies. The middle or mezzanine

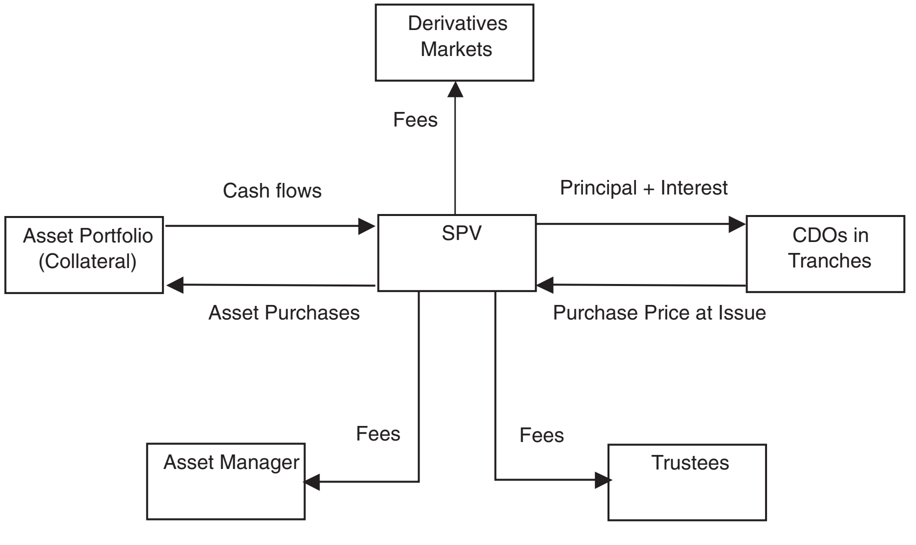

Figure 19.6 Basic CDO structure

tranches are sold to investors who are prepared to take on more default risk for a higher yield. The equity tranche is the most subordinated and has the highest default risk. It may be attractive to more speculative investors such as hedge funds.

One of the key features of a CDO is that its value depends entirely on the performance of the asset pool and not on that of the creditworthiness of the entity or entities that originally created the assets (such as a commercial bank).

RATIONALE FOR SECURITIZATION

Some CDO structures are what is known as **balance sheet CDOs**. If a bank originates a loan portfolio and retains the assets on its balance sheet it is required by the regulators to set aside capital against potential losses.

However the bank can sell the assets to an SPV which funds the purchase by issuing CDOs. The bank reduces its credit risk and the capital it has to hold against this risk. It also frees up cash which it can use to create further loans. In some cases it may be able to sell off nonperforming loans. The investors in the CDOs gain an exposure to loan portfolios they could not access directly. At the time of writing (early 2010) regulators are still debating over the extent to which the ability of banks to move loan assets off their balance sheets should be curtailed.

Arbitrage CDOs

Most CDO structures are what is known as **arbitrage CDOs**. These are assembled by a sponsor which arranges the purchase, restructuring and management of a portfolio of bonds or loans. Normally rules are set specifying the composition of the portfolio. The sponsor may be a fund manager or a bank. It can seek to profit by making more money on the asset portfolio than it pays out on the CDOs, or it may just take a management fee.

In some cases the individual assets in the portfolio may be illiquid or unattractive to investors by themselves (and hence cheap to buy). However by pooling them together the sponsor can create CDOs in different tranches that appeal to various classes of investors.

The future of the CDO market

At the time of writing it remains to be seen to what extent the regulators will tighten up on CDO issuance and restrict the market for securitized debt.

In the ‘credit crunch’ which started in 2007 and which accelerated in 2008, financial institutions were left holding what became known as ‘toxic assets’, especially securities backed by failing US mortgage loans. The ‘toxic assets’ became illiquid, so that it was impossible to establish their value and the extent of the losses suffered by investors. Major financial institutions suffered due to their exposure to the bad debts as well as their problems in securing short-term funding in the money markets (see Chapter 1).

SYNTHETIC CDOs

In a synthetic CDO structure the collateral is a portfolio of single name credit default swaps rather than loans or bonds. (Credit default swaps are explained in Chapter 7 above.)

The arranging or sponsoring organization (typically a bank) enters into a set of CDS contracts with the SPV which sells credit protection and receives the CDS premiums. The premiums

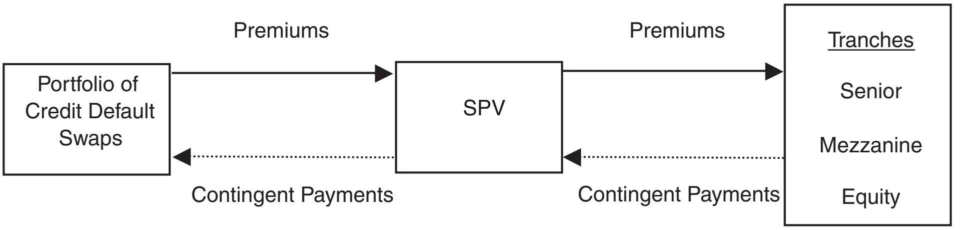

Figure 19.7 Synthetic CDO structure

are passed over to the CDO investors, who assume credit risk on the names in the portfolio of CDS contracts. If different tranches of CDOs are issued, the lowest ranking classes suffer the first losses on the swap portfolio.

Individual tranches can be in **unfunded form**, which means that the investors are simply paid their share of the premiums from the CDS portfolio. Or they can be in **funded form**, like a credit-linked note: the investors pay a par value for the notes at the outset and earn an enhanced return, including their share of the premiums, but risk losing some or all of their capital if defaults occur on the names in the portfolio of CDS contracts. Many variants have been developed, but Figure 19.7 illustrates a very simple example of a synthetic CDO structure.

For example, suppose the underlying portfolio consists of 100 credit default swaps each on \$10 million notional. The total notional is therefore \$1 billion. The (unrated) equity tranche assumes the first 3% or \$30 million of losses. It is paid a high premium. The mezzanine tranche is rated BBB and suffers the next \$70 million of losses. It is paid a lower premium. The top-rated AAA-rated senior tranche on the remaining \$900 million takes the remaining losses and is paid the lowest premium.

Risk on the AAA tranche

In theory the AAA tranche here is very safe because it would only be affected by a very high level of defaults. If the average recovery rate on the names in the portfolio is one third then the senior tranche is protected against 15 defaults in the CDS portfolio.

$$\text{Loss on portfolio from 15 defaults} = 15 \times \$10 \text{ million} \times \frac{2}{3} = \$100 \text{ million}$$

The portfolio of CDS may be static or it may be actively managed by an asset manager to maximize the returns.

There may be as many as seven tranches in a deal. If the senior tranche is rated AAA and if the portfolio could suffer several defaults before it is affected it may be called **super senior**. The next tranche down may then be called the senior tranche.

Single Tranche CDOs

These are customized deals arranged between a bank and a client. The two parties agree on the nature of the CDS portfolio and the level of subordination the investor will take, e.g. at the mezzanine level. The advantage for the investor is that it can take exactly the type and level of credit risk exposure it wants. The advantage for the arranging bank is that it does not have to find investors willing to buy all the tranches.

CHAPTER SUMMARY

Derivatives are not only used for trading and risk management. They are also used to create a wide range of structured securities whose returns depend on such factors as the value of a portfolio of shares, currency exchange rates or the level of interest rates over a period of time. Banks also use derivatives to package up the risks they acquire as part of their business operations and ‘sell them off’ to investors in the form of bond issues.

The equity-linked note (ELN) is a typical structured product. Normally investors in ELNs are offered a level of capital protection plus participation in any rise in the value of an equity index or a specific basket of shares. The product can be assembled by depositing a sum of money to guarantee the principal repayment and buying a call on the index or basket. The profits on the notes may be capped or based on the average value of the index or basket. It may be structured such that interim gains are locked in.

Securitization is the process of selling bonds to investors that are repaid from the cash flows generated by a pool of assets such as mortgage loans. In a CDO structure the assets are transferred into a special purpose vehicle (SPV). Typically, the SPV sells different classes of bonds with different risk-return characteristics and credit ratings. The SPV collects cash generated by the asset pool and makes due payments to the bondholders.

In a synthetic securitization the SPV does not purchase actual debt assets. Instead it enters into a set of credit default swap (CDS) deals in which it sells credit protection and earns premium income. This is passed over to the investors in the synthetic CDOs, who assume credit risk on the names in the portfolio of CDS contracts. If different tranches of CDOs are issued, the lowest ranking classes suffer the first losses on the CDS portfolio.

20

Clearing, Settlement and Operational Risk

INTRODUCTION

The settlement of exchange-traded derivatives is guaranteed by the clearing house associated with the exchange. The risk of default is greatly reduced by this and by the use of margining procedures. At the time of writing, there is considerable debate on how the default risk on over-the-counter (OTC) derivatives should be managed in future.

However it must not be forgotten that the fall of Barings Bank was largely caused by failings in the operational procedures supporting trading activities in straightforward exchange-traded derivative contracts (see Chapter 1).

This means that banks dealing in derivatives have to put in place stringent controls not just on the more exotic OTC contracts, but also on standard or 'vanilla' products, including exchange-traded futures and options. This chapter examines the basic operational procedures relating to clearing and settling derivatives and the associated risks and controls.

RISK MANAGEMENT IN GENERAL

Financial institutions dealing in derivatives face a wide range of risks. Three of the most obvious are market risk, counterparty risk and operational risk.

- **Market Risk**. Potential losses resulting from changes in market variables such as stock prices, currency rates, bond prices and interest rates. It is also known as price risk.
- **Counterparty Risk**. Potential losses resulting from the failure of a counterparty to fulfil its contractual obligations, e.g. by settling trades, delivering securities or making margin payments on due dates.
- **Operational Risk**. Potential losses resulting from failures in operational procedures and systems and human errors. It also arises from cases where 'rogue traders' are able to circumvent control procedures.

One way that derivatives dealing rooms manage market risk is to impose **position limits** on traders. They also employ sophisticated risk management tools such as value-at-risk calculations and stress testing.

Value-at-Risk (VaR)

VaR is a statistical estimate of the maximum loss likely to be made on a trading position over a given period of time, and with a given level of confidence. For example, at a 99% confidence level the expectation is that there is only one chance in 100 that the actual loss on a position over a specified time period will exceed the VaR figure. One problem with the method is that it may not capture the risks posed by extreme events such as a market crash. Stress testing can augment VaR and investigate the potential effects of such extreme events.

In many cases, the **counterparty risk** faced by a derivatives trader takes the form of a replacement risk. The trader has a portfolio of transactions, some of which will offset each other. If a counterparty fails to complete a deal this will have to be replaced with a new trade to manage the overall risk on the dealing book. However the current market price or rate for doing this may be less advantageous than the price or rate originally dealt on.

In addition to the three types of risk mentioned above, banks operating in the high-risk derivatives business also face a **reputational risk**. Mistakes and failures (and outright fraud) of the kinds described in Chapter 1 can have a devastating effect on the reputation of a financial institution. It may take years to recover, or the business may have to be closed down completely or be taken over by another organization.

SETTLEMENT OF EXCHANGE-TRADED DERIVATIVES

As discussed in Chapters 4 and 5, the settlement of exchange-traded futures and option contracts is guaranteed by the **clearing house** associated with the exchange. The clearing house (or 'clearer') acts as the central counterparty (CCP) to both sides of a transaction. It 'sits in the middle' of a trade once it is made, and becomes the buyer to the seller and the seller to the buyer. (In contract law this procedure is called **novation**.)

The key advantage of the clearing system is that it greatly reduces counterparty risk. Instead of many counterparties there is only one. To manage its risks, the clearing house collects collateral known as **initial margin** when a position is opened (CME Clearing calls it a 'performance bond'). Furthermore, positions are regularly **marked-to-market** to ensure that trading losses do not accumulate over time. Traders who are losing money are subject to **margin calls** which means that they have to deposit additional collateral to maintain their positions.

Initial margin requirements vary between different kinds of derivative products and markets, and are based on volatility and other factors. In more extreme market conditions a clearing house may increase the initial margin requirement during a trading day.

Clearing Members

Only the **clearing members** have direct accounts with the clearing house. These are major, well-capitalized financial organizations. If a client uses a broker which is a member of the exchange but not a clearing member to transact an order, then the broker has to make any due payments to the clearing house via a clearing member. The clearing member takes responsibility for all transactions conducted through it. (See Figure 20.1.)

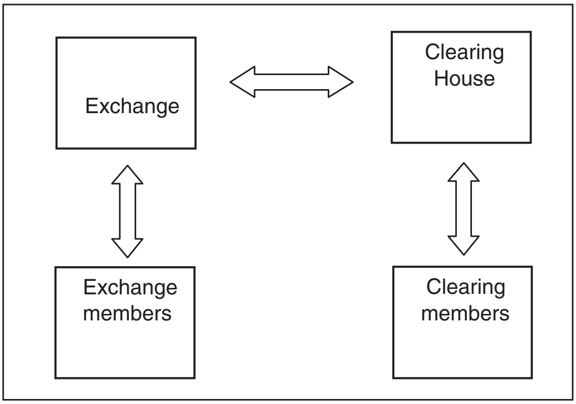

Figure 20.1 Links between derivatives exchange and clearing house

The clearing house sets stringent financial and other criteria (such as operational capability) which clearing members must meet. This is vital because the clearing members register and act as intermediaries for client transactions.

The clearing house manages the settlement procedures for futures and options. As discussed in Chapter 4, some exchange-traded contracts result in the physical delivery of a financial asset or a commodity by one party, in return for a payment by the counterparty. In other cases, such as the interest rate and equity index futures contracts described in Chapter 5, there is no physical delivery but only a cash settlement process.

Finally, the clearing house manages the **assignment** process for the exercise of options. If an option is exercised a trader who is short the relevant contract is randomly selected to fulfil the obligations of the contract (via a clearing member).

MAJOR CLEARING HOUSES

Some clearing houses are divisions of a derivatives exchange, whilst others are independent organizations. They are overseen by regulatory bodies such as the Securities and Exchange Commission (SEC) and the Commodity Futures Trading Commission (CTFC) in the US, and the Financial Services Authority (FSA) in the UK.

The following are a few of the most important global clearing houses:

- **Options Clearing Corporation (OCC)**. It was founded in 1973 and is the world's largest equity derivatives clearing organization. OCC clears trades for a range of participant exchanges including the Chicago Board Options Exchange (CBOE). It is overseen by a Board of Directors mainly drawn from the clearing members. It functions as an 'industry utility' and derives most of its revenues from clearing fees charged to members.
- **CME Clearing**. It is an operating division of CME Group. It has been clearing trades for over 100 years. Nowadays it provides services for CME Group as well as other exchanges such as OneChicago. It also clears OTC derivatives. Like OCC, CME Clearing is a registered Derivatives Clearing Organization (DCO) in the US.
- **LCH.Clearnet Group**. It was formed from the 2003 merger of the London Clearing House (LCH) and Clearnet SA. It is an independent entity providing clearing services for NYSE

Liffe, the London Metal Exchange (LME), and other financial markets such as the London Stock Exchange. It also provides clearing services for over-the-counter derivatives contracts such as interest rate swaps. LCH dates back to 1888.

In continental Europe, **Eurex Clearing** is a subsidiary of Eurex Frankfurt AG and is jointly operated by Deutsche Börse AG and SIX Swiss Exchange. It clears Eurex derivatives trades and also transactions on the Frankfurt Stock Exchange. The derivatives it handles are based on a wide range of underlyings including equities, interest rates and credit. Like other clearing houses, it also generates important data and reports for users and regulators.

Barings Bank

Chapter 1 discussed the Barings Bank collapse in 1995. At the time Barings Futures Singapore (BFS) was one of the largest clearing members on the Singapore International Monetary Exchange (SIMEX). It held around $480 million in margin funds on behalf of customers when Barings went bankrupt. In the event all the funds were returned to the customers. The process was expedited by the acquisition of Barings by ING in March 1995.

CONFIRMATION AND SETTLEMENT OF OTC DEALS

An OTC derivative is a bilateral legal agreement made directly between two parties and not on an organized exchange. As such, it can be specially tailored (although in practice many trades are quite standard). There is also the potential risk with an OTC transaction that one party may default and fail to fulfil its legal obligations.

In the past one of the problems with the OTC market was the lack of agreed legal documentation. This was tackled through the creation of **master agreements** by bodies such as the International Swaps and Derivatives Association (ISDA). ISDA represents the OTC derivatives industry globally and develops the ISDA Master Agreement and a wide range of related documentation covering a variety of transaction types. In the forward rate agreement market (see Chapter 3) standard legal terms are developed by the British Bankers' Association.

Before any OTC deal is transacted, a bank has to ensure that master agreement documentation is exchanged and signed. A **confirmation** (or 'confirm') details the terms of a specific deal between the two parties covered by the master agreement. Confirmation must be concluded before any movements of cash or securities. In a deal between two banks both sides will typically send a confirmation. Increasingly, the process is automated. In a transaction between a bank and a client the bank may send a confirmation for the client to sign and return.

Default risk on OTC deals

Individual banks dealing in OTC derivatives can manage and mitigate default risk on trades by taking collateral from clients and other counterparties, and by marking-to-market their trading positions on a regular basis.

Despite such techniques, however, the potentially calamitous effects of the failure of one or more of the major financial institutions operating in the global OTC derivatives market remains. If a large bank defaulted and was unable to settle its trades there would be a serious risk of a **systemic collapse** in the whole financial system.

As discussed in Chapter 1, the world came close to this point after the bankruptcy of Lehman Brothers in September 2008. Market participants were uncertain about the knock-on effects on other financial institutions. A lack of confidence in the stability of trading counterparties spread throughout the markets. It required sustained and heavy intervention by governments and central banks in the US and globally to avert disaster.

CONTROLLING COUNTERPARTY RISK ON OTC DERIVATIVES

In the wake of such events, a number of measures to prevent systemic failures and 'domino effects' amongst banks have been put in place around the world. One is to strengthen the powers and controls available to the regulators. Another is to increase the amount of capital that financial institutions hold against risky positions.

In addition, regulators in the US and elsewhere have pressed derivatives dealers to increase the use of central clearing arrangements for OTC derivative trades. This involves registering a privately negotiated deal with a clearing house, which takes and manages collateral from both parties. The clearing house 'stands in the middle' and guarantees the performance of the transaction.

According to a paper published by the New York Federal Reserve in January 2010, only about 35% of the gross outstanding in the OTC interest rate derivatives market was cleared as at end-2009.

One possibility is to pass legislation *requiring* the use of clearing arrangements for OTC derivatives trades. This would raise the question of whether OTC deals involving nonfinancial firms should be exempt from such a law. If not, it could make OTC transactions highly unattractive to corporations using derivatives to manage their interest rate and other risks. They would have to lodge initial margin, and would also be subject to regular margin calls. This could cause funding problems and could also increase the volatility of corporate earnings.

At the time of writing (early 2010) lawmakers are discussing less restrictive proposals, that in future OTC derivatives should be standardized wherever possible and centrally cleared. More complex OTC deals would be exempt from central clearing, but would have to be reported. One open question is *how many* clearing houses are required. No matter how well capitalized and managed they are, there are risks involved in concentrating risk in a few entities.

OPERATIONAL RISK

In recent years banks and regulators have become increasingly aware of the additional dangers posed by **operational risk**.

According to a definition proposed by the Basel Committee on Banking Supervision in 2002, operational risk is the risk of loss resulting from failed or inadequate internal procedures, people and systems or from external events. Failure to manage operational risk properly can affect a firm's profitability, but it can also badly damage its reputation in the market. Specific areas where problems can arise include the following.

Trade capture

When a deal is made the details must be properly recorded. Nowadays this is often done by the trader or an assistant entering the details into a computer system. From there the information flows through to the bank's operations or 'back-office' systems. Operations staff are responsible for ensuring that correct data (including settlement instructions) are captured and that anomalies are corrected.

Confirmation

The confirmation of a trade is legal evidence that it has been agreed. Some of the examples in Chapter 1 show what can happen if confirmation procedures are flouted or poorly executed.

Settlement

Settlement occurs when payment is made for a trade. Instructions must be sent on time and payments must be made to the correct account. Settlement errors can be costly. If a bank fails to make a due payment it will have to compensate the counterparty. A failure may also affect its funding position.

Nostro reconciliation

A Nostro account is a bank's account with another bank. Nostro reconciliation is designed to ensure both that a trade has settled properly and that the correct payments have been made as expected. It involves checking that the expected cash movements resulting from trades are reflected in the actual movements of cash in the Nostro bank. Nowadays the process is highly automated.

Position valuation

Valuation involves establishing the correct current value of trades and of trading books. The key principle here is that valuation should be verified by staff who are separate from the sales and trading function, to ensure an independent check.

If there is an active and liquid market for an asset then the market value can be used for position valuation. This is the case with standardized products such as exchange-traded contracts. In less liquid markets or with more exotic or structured derivatives, position valuation can be checked against data obtained from independent sources such as brokers or other banks. The pricing models used by traders dealing in more exotic products may also be independently evaluated.

Collateral and funding management

Collateral management is the process of ensuring that margins are paid and collected. A failure to collect adequate collateral from clients will increase the risk that a derivatives operation will suffer from counterparty default. Funding management includes arrangements for ensuring that adequate and timely funds are available in the correct currencies to settle all trades.

Management information systems (MIS)

Proper systems have to be put in place to generate relevant management reports and warnings about problem areas in the business. Mistakes in this area will result in failures to take corrective measures, leading to losses and potential disputes with the regulatory bodies.

BEST PRACTICE IN OPERATIONAL RISK MANAGEMENT

The industry works hard at developing ‘best practice’ in these areas. It trains and develops its staff, and spends huge sums of money on new information and communications technology designed to automate operational procedures. Nevertheless, as Chapter 1 shows, it is very hard to eradicate all the operational risks in a business. In particular, from time to time a ‘rogue trader’ seems to find a way through whatever controls are in place.

One of the major areas for improvement for the future of the derivatives industry is the recruitment, training, management and indeed the status of the internal support staff working in banks. The derivatives industry needs risk control and operations people who are able to exert real control over the activities of traders and other front-office staff who occupy powerful (and very highly paid) positions within their organizations.

Segregation of duties

The Barings Bank example has demonstrated the vital importance of segregating the trading function in a bank from the settlement operation. There are a number of ‘best practice’ rules that reinforce this separation:

- There should be separate reporting lines for the trading and for the settlement functions.
- Traders should never have the sole authorization to make a payment on a trade.
- Traders should never have sole responsibility for the revaluation of open trades, and should not be the unique source of data used for revaluation and profit and loss calculations.
- Traders should never have sole responsibility for developing pricing models.
- No one single individual should enter data for a trade, authorize a payment and reconcile the movements of cash and securities.

To back this up, banks impose strict controls on the use of computer passwords, to safeguard access to information and systems. They require staff to take holidays consisting of at least 10 consecutive business days. This helps to ensure that all activities are seen and monitored by other people in the organization. The key principle is that no one individual should be the only person solely responsible for all aspects of a transaction.

CHAPTER SUMMARY

A bank trading derivatives faces market risk, counterparty risk and operational risk. Mistakes or malpractice may also affect its reputation. Market risk relates to losses arising from movements in variables such as interest rates, bond prices and share prices. Traders are given position limits to ensure that they do not take too much risk. Their activities are monitored by risk control specialists using tools such as value-at-risk and stress tests.

Counterparty risk on exchange-traded derivative contracts is virtually eliminated because the clearing house acts as central counterparty. It guarantees the performance of trades and takes collateral from traders. Only clearing members deal directly with the clearing house. Other traders have to ‘clear’ their transactions through a clearing member. Clearing houses are either independent organizations or subsidiaries of exchanges.

An over-the-counter (OTC) derivative transaction is privately negotiated between the two parties and is not dealt on an exchange. Normally the two parties sign a master legal agreement. The specific terms of an individual deal covered by the master agreement are described in a confirmation. This may be automated. There is a potential counterparty risk with OTC deals that one side may fail to fulfil its contractual obligations. This can be managed by exchanging collateral and marking positions to market. Deals can also be registered with a clearing house which takes over the management of collateral and provides a guarantee against default.

Operational risk is the risk of losses resulting from failures in procedures, people, systems or external events. Examples include mistakes in confirming and settling trades and in reconciling the cash movements in bank accounts with information about trades. The derivatives industry and the regulators develop 'best practice' rules to mitigate operational risk and failures. One key rule is that no single individual should be responsible for all aspects of a transaction. This is designed to help prevent episodes such as the collapse of Barings Bank.

Appendix A
Financial Calculations

TIME VALUE OF MONEY

Time value of money (TVM) is a key concept in modern finance. It tells us two things:

- \$1 received today is worth more than \$1 to be received in the future.
- \$1 to be received in the future is worth less than \$1 received today.

The reason for this is because \$1 today can be invested at a rate of interest and will grow to a larger sum of money in the future. The cost of money for a specific period of time (its time value) is measured by the interest rate for the period. Interest rates in the financial markets are normally quoted on a **nominal per annum** basis.

Real and nominal interest rates

A nominal interest rate has two components:

- **Real Rate**. This compensates the lender for the use of the funds over the period.
- **Inflation Rate**. This compensates the lender for the predicted erosion in the value of money over the period.

Normally the inflation element is more subject to change than the real or underlying rate. The relationship between the two can be expressed mathematically (with the rates inserted in the formulae as decimals).

$$1 + \text{Nominal rate} = (1 + \text{Real rate}) \times (1 + \text{Inflation rate})$$

$$\text{Real rate} = \frac{1 + \text{Nominal rate}}{1 + \text{Inflation rate}} - 1$$

If the nominal or quoted interest rate for one year is 5% p.a. (0.05 as a decimal) and the predicted rate of inflation over the period is 3% p.a. (0.03 as a decimal) then the real interest rate is calculated as follows.

$$\text{Real rate} = \frac{1.05}{1.03} - 1 = 0.0194 = 1.94\%$$

In the financial markets interest rates are usually quoted on a per annum basis. To calculate the interest due on a loan or deposit that matures in less than one year the annualized rate is reduced in proportion.

FUTURE VALUE (FV) WITH PERIODIC COMPOUNDING

Suppose an investor deposits \$100 for one year with a bank. The interest rate is 10% p.a. simple interest, that is, without compounding. The principal amount invested is called the **present value** (PV). The principal plus interest at maturity is called the **future value** (FV).

The interest rate as a decimal is 0.1, i.e. 10 divided by 100.

$$\text{FV} = \text{Principal} + \text{Interest at maturity}$$
$$\text{FV} = \$100 + (\$100 \times 0.1) = \$100 \times 1.1 = \$110$$
$$\text{Interest at maturity} = \$100 \times 0.1 = \$10$$

This is a **simple interest** calculation because there is no compounding or 'interest on interest' involved. Note that if an investor deposits \$100 for one year and is credited with \$110 at maturity it is possible to work out that the simple interest return earned on the investment is 10% p.a.

Compound interest calculation

Suppose now an investor deposits \$100, but this time for two years at 10% p.a. and interest is compounded at the end of each year. What is the future value (FV) after two years? At the end of one year there is $100 \times 1.1 = \$110$ in the account. To work out the FV at the end of two years, multiply this by 1.1 again.

$$\text{FV} = \text{Principal} + \text{Interest at maturity}$$
$$\text{FV} = \$100 \times 1.1 \times 1.1 = \$100 \times 1.1^2 = \$121$$

Because of compounding the interest amount at maturity is \$21. The first year's interest is \$10. The second year's interest is \$11. In addition to interest on the original principal of \$100, there is \$1 interest on interest.

Compound interest formula

The general formula for calculating a future value when interest is compounded periodically is as follows.

$$\text{FV} = \text{PV} \times \left(1 + \frac{r}{m}\right)^n$$

where:

FV = future value
PV = present value
r = the interest rate p.a. as a decimal (the percentage rate divided by 100)
m = the number of times interest is compounded each year
n = the number of compounding periods to maturity = years to maturity $\times\ m$.

In the previous example interest was compounded only once a year and it is a two-year deposit, so the values are as follows:

PV = 100
$r = 0.1$
$m = 1$
$n = 2$
$\text{FV} = 100 \times 1.1^2 = 121$

Semi-annual compounding

There are many investments where interest is compounded *more* than once a year. For example, the calculations for US Treasury bonds and UK gilts are based on six-monthly periods. This is known as **semi-annual compounding**. Other investments pay interest every three months. Credit cards often charge interest on unpaid balances on a monthly basis.

Suppose an investor deposits \$100 for two years at 10% p.a. Interest is compounded every six months. What is the future value at maturity in this case?

$$\text{FV} = \$100 \times \left(1 + \frac{0.1}{2}\right)^4 = \$121.55$$

The annual rate expressed as a decimal is divided by two to obtain a six-monthly rate. Compounding is for four half-yearly periods. The future value is higher than when interest was compounded annually. This illustrates a basic principle of TVM. It is better to earn interest sooner rather than later, since it can be reinvested and will grow at a faster rate.

ANNUAL EQUIVALENT RATE (AER)

Because interest rates in the market are expressed with different compounding frequencies it is important to be very careful when comparing rates. For example, suppose two investments are available. The maturity in both cases is one year, but the first investment offers a return of 10% p.a. with interest compounded annually. The second offers a return of 10% p.a. with interest compounded semi-annually. Which is better?

The answer is the semi-annual investment, since the interest paid half-way through the year can be reinvested for the second half of the year. And yet the quoted rate (10% p.a.) looks exactly the same in both cases.

This shows that 10% p.a. with semi-annual compounding cannot be directly compared with a 10% p.a. rate with annual compounding. In fact 10% p.a. with semi-annual compounding is equivalent to 10.25% p.a. with annual compounding. This can be demonstrated using TVM. Suppose an investor deposits \$1 for a year at 10% p.a. with semi-annual compounding. The present value is \$1. The future value at maturity is calculated as follows:

$$\text{FV} = \$1 \times \left(1 + \frac{0.1}{2}\right)^2 = \$1.1025$$

The interest amount here is \$0.1025. This is the same amount of interest the investor would earn from investing \$1 for one year at 10.25% p.a. with annual compounding.

AER examples

This calculation is the basis for what is known as the **annual equivalent rate** (AER) or the effective annual rate. It measures the rate expressed with annual compounding that is equivalent to a rate expressed with interest compounded at more frequent intervals, such as twice a year. For example, a rate of 10% p.a. with semi-annual compounding is equivalent to 10.25% p.a. expressed with annual compounding (i.e. the AER is 10.25% p.a.).

Table A.1 sets out some other examples. For example, a nominal or quoted interest rate of 10% p.a. with daily compounding is equivalent to 10.5156% p.a. with interest compounded once a year.

Table A.1 Annual equivalent rates

Nominal rate p.a.	Compounding frequency	AER
10%	Annually	10.0000%
10%	Semi-annually	10.2500%
10%	Quarterly	10.3813%
10%	Daily	10.5156%

AER formula

The formula for calculating the AER when interest is compounded *m* times per annum is as follows:

$$\text{AER} = \left(1 + \frac{\text{Nominal Rate}}{m}\right)^m - 1$$

For example, a nominal rate of 10% p.a. with semi-annual compounding is equivalent to 10.25% p.a. with annual compounding.

$$\text{AER} = \left(1 + \frac{0.1}{2}\right)^2 - 1 = 0.1025 = 10.25\%$$

Once potential source of confusion in the financial markets is the way that people refer to interest rates. A rate said to be '10% semi-annual' does not usually mean an interest rate of 10% every six months. It normally means a rate of 10% p.a. with semi-annual compounding. The rate every six months is actually half of 10% which is 5%.

PRESENT VALUE (PV) WITH PERIODIC COMPOUNDING

It is also possible to calculate the value in today's terms of a cash flow due to be received in the future. The basic time value of money formula with periodic compounding is as follows:

$$\text{FV} = \text{PV} \times \left(1 + \frac{r}{m}\right)^n$$

This can be rearranged to solve for the present value (PV):

$$\text{PV} = \frac{\text{FV}}{\left(1 + \frac{r}{m}\right)^n}$$

In this version of the formula r is known as the **discount rate**. This formula calculates the value in today's terms of cash to be received in the future. This has very wide applications in financial markets.

For example, a debt security such as a bond is simply a title to receive future payments. With a 'straight' bond the investor receives a series of interest payments, known as coupons, plus the par or face value of the bond which is repaid at maturity. With a zero-coupon bond the par value is repaid at maturity but there are no coupon payments. It will trade at a discount to its par value.

Valuing a zero coupon bond

An investor is deciding how much to pay for a 20-year zero-coupon bond with a par value of \$100. The return on similar investments is currently 10% p.a. expressed with annual compounding. Applying the TVM formula, the fair value of the bond is calculated as follows.

$$\text{PV} = \frac{\$100}{1.12^{20}} = \$14.8644$$

The discount rate is the return currently available on similar investments with the same level of credit (default) risk and the same maturity. This establishes a required rate of return and hence a fair value for the bond. Economists would call it the 'opportunity cost of capital' – the return that could be achieved on comparable investments if money is not tied up in the bond.

Valuing a coupon bond

This above methodology is extended to pricing coupon bonds, i.e. bonds that make regular interest payments during their life. Suppose an investor buys a bond that pays an annual coupon of 10% p.a. The par or face value is \$100 and the bond has exactly three years remaining to maturity. How much is it worth today, if the rate of return on similar investments in the market is currently 12% p.a. expressed with annual compounding?

The traditional valuation methodology is to establish the cash flows on the bond, discount each cash flow at a constant rate, then sum the present values:

- The cash flow in one year is \$10, an interest payment of 10% of the \$100 face value. Its PV discounted at 12% for one year is \$10/1.12 = \$8.9286.
- The cash flow in two years is another interest payment of \$10. Its PV discounted at 12% for two years is $\$10/1.12^2 = \$7.9719$.
- The cash flow in three years is a final \$10 interest payment plus the payment of the bond's \$100 face value, a total of \$110. Its PV discounted at 12% for three years is $\$110/1.12^3 = \$78.2958$.

The sum of the PVs is \$95.2. This establishes a fair market price for the bond. The bond is trading below its face value of \$100 because it pays a fixed coupon of only 10% p.a. in a current market environment in which the going annual return for investments of this kind is 12% p.a. In economic terms, investors will tend to sell the bond and switch into the higher-yielding investments now available, until its price is pushed below its \$100 face value and stabilizes at around \$95.2.

CONTINUOUSLY COMPOUNDED INTEREST RATES

Option pricing models tend to use continuously compounded rates rather than periodically compounded rates to calculate future values and to discount future cash flows, such as the exercise or strike price of a European-style call or put. Future and present values with continuously compounded rates are calculated as follows:

$$\text{FV} = \text{PV} \times e^{rt}$$
$$\text{PV} = \text{FV} \times e^{-rt}$$

where:

FV = future value
PV = present value
r = the continuously compounded interest rate p.a. as a decimal
t = time in years
e = the base of natural logarithms $\approx$ 2.71828.

Continuous compounding examples

What is the future value of \$100 invested for two years at a continuously compounded rate of 10% p.a.?

$$\text{FV} = \$100 \times e^{0.1\times 2} = \$122.1403$$

What is the present value of \$100 to be received in three years if the continuously compounded rate of interest for the period is 5% p.a.?

$$\text{PV} = \$100 \times e^{-0.05\times 3} = \$86.0708$$

Note that in Excel the function EXP() calculates e to the power of the number in the brackets.

Annual Equivalent Rate (AER)

The AER where interest is compounded continuously is calculated as follows:

$$\text{AER} = e^{r} - 1$$

Where r is the continuously compounded rate p.a. as a decimal. For example, a quoted interest rate of 10% p.a. expressed with continuous compounding is equivalent to 10.5171% p.a. with annual compounding:

$$\text{AER} = e^{0.1} - 1 = 0.105171 = 10.5171\%$$

In other words, an investment that pays 10% p.a. with continuous compounding offers the same effective annual return as an investment that pays 10.5171% p.a. where interest is compounded only once a year.

YIELD OR RETURN ON INVESTMENT

The basic time value of money formula with periodic compounding is as follows:

$$\text{FV} = \text{PV} \times \left(1 + \frac{r}{m}\right)^{n}$$

Given a present value and a future value, it is also possible by rearranging the formula to calculate the periodic **rate of return** achieved on an investment:

$$\text{Rate of return} = \left(\sqrt[n]{\frac{\text{FV}}{\text{PV}}} - 1\right) \times m$$

where:

FV = future value
PV = present value
m = the number of times interest is compounded per year
n = the number of compounding periods to maturity = years to maturity $\times\ m$.

Rate of return example

An investor deposits \$100 for three years. The future value due at maturity is \$125. There are no intervening cash flows. The annualized rate of return expressed with different compounding frequencies is as follows:

$$\text{Annually compounded return} = \left(\sqrt[3]{\frac{125}{100}} - 1\right) \times 1 = 0.0772 = 7.72\% \text{ p.a.}$$

$$\text{Semi-annually compounded return} = \left(\sqrt[6]{\frac{125}{100}} - 1\right) \times 2 = 0.0758 = 7.58\% \text{ p.a.}$$

The rate of 7.58% p.a. is a semi-annually compounded rate. Its AER, i.e. its equivalent expressed with annual compounding, is 7.72% p.a.

Continuously compounded return

Where r is a continuously compounded rate, we have the following equation:

$$\text{FV} = \text{PV} \times e^{rt}$$

This can be rearranged to calculate a continuously compounded rate of return:

$$\text{Continuously compounded return} = \frac{\ln\left(\dfrac{\text{FV}}{\text{PV}}\right)}{t}$$

where:

ln () = the natural logarithm of the number in brackets
t = time to maturity in years.

Suppose an investor deposits \$100 for three years and is due to receive \$125 at maturity. There are no intervening cash flows:

$$\text{Continuously compounded return} = \frac{\ln\left(\dfrac{125}{100}\right)}{3} = 0.0744 = 7.44\% \text{ p.a.}$$

A rate of 7.44% p.a. with continuous compounding is equivalent to 7.72% p.a. with annual compounding, i.e. the AER is 7.72%. The Excel function that calculates the natural logarithm of a number is LN(). It is the inverse of the EXP() function.

TERM STRUCTURE OF INTEREST RATES

In developed markets such as the US the minimum rate of return on an investment for a given maturity period is established by the return on Treasury (government) securities. It is sometimes called the **risk-free rate,** reflecting the fact that the chance of default by such an issuer is very small (though in fact it is not exactly zero).

The **term structure** shows the returns on Treasury zero-coupon securities for a range of different maturity periods. Why not use coupon-paying securities? The problem is that the return on a coupon bond depends to some extent on the rate at which coupons can be reinvested during the life of the security. To calculate a return it is necessary to make assumptions about future reinvestment rates. A zero-coupon bill or bond is much simpler. Because there are no coupons, no assumptions need be made about reinvestment rates.

Using the term structure

Zero-coupon rates are also known as **spot rates**, and working with spot rates has many advantages. Firstly, as stated previously, they can be used to calculate future values without making any assumptions about future reinvestment rates. Secondly, they can be used as a reliable and consistent means of discounting future cash flows back to a present value. A one-year risk-free cash flow should be discounted at the one-year Treasury spot rate; two-year risk-free cash flows should be discounted at the two-year Treasury spot rate; and so on.

A non-Treasury security such as a corporate bond is valued by discounting the cash flows at the appropriate Treasury spot rates plus a premium or spread that reflects the additional credit and liquidity risk of the bond. For example, if the bond pays a coupon in one year this should be discounted at the one-year Treasury spot rate plus a spread; if it pays a coupon in two years this should be discounted at the two-year Treasury spot rate plus a spread; and so on.

Just as importantly, spot rates can be used to calculate **forward interest rates**, which are used in the pricing of interest rate forwards, futures, swaps and options. The next section shows how forward rates can be extracted from spot or zero-coupon rates.

CALCULATING FORWARD INTEREST RATES

Table A.2 shows spot or zero-coupon rates for different maturity periods, expressed with annual compounding. These are based on interbank lending rates rather than Treasuries, so they incorporate a spread over the risk-free Treasury spot rates.

Table A.2 Spot or zero-coupon interest rates

Spot rate	Value (% p.a.)
Z_{0v1}	4.00
Z_{0v2}	5.00
Z_{0v3}	6.00

In Table A.2 the rates are as follows:
Z_{0v1} is the rate of return applying to a time period starting now and ending in one year. In our examples, cash flows that occur in one year will be discounted at this rate.

Z_{0v2} is the rate of return that applies to a time period starting now and ending in two years. Cash flows that occur in two years will be discounted at this rate.

Z_{0v3} is the three-year spot or zero-coupon rate, the rate at which three-year cash flows will be discounted.

Calculating forward rates: example

The forward interest rate between years one and two can be calculated from the term structure in Table A.1, using an arbitrage argument. Call that forward rate F_{1v2}. It is the rate of return that applies to investments made in one year that mature two years from now. Also, when discounting a cash flow that occurs in two years back to a present value one year from now, the cash flow should be discounted at F_{1v2}. To discount *this* value in one year back to a present value now, it should be further discounted at the one-year spot rate Z_{0v1}.

Suppose a trader borrows \$1 now for two years at the two-year spot rate of 5% p.a. The trader takes this cash and deposits the money for one year at 4% p.a., the one-year spot rate. Suppose further that the trader could agree a deal with someone that allowed the trader to reinvest the proceeds from this deposit in a year for a further year at (say) 8% p.a. with annual compounding. The cash flows in two years' time would look like this:

- Principal plus interest repaid on loan = \$1 $\times$ 1.05^2 = \$1.1025
- Proceeds from one-year deposit at 4% p.a. reinvested for a further year at 8% p.a. = \$1 $\times$ 1.04 $\times$ 1.08 = \$1.1232.

This is an arbitrage. In two years' time the trader repays \$1.1025 on the loan but achieves \$1.1232 by investing the funds for a year and then rolling over the deposit for a further year. Since it is unlikely that such 'free lunches' will persist for long, this shows that it is unlikely that anyone would enter into a deal that allowed the trader to reinvest for the second year at 8% p.a.

The fair forward rate F_{1v2} is the rate for reinvesting money in one year for a further year such that no such arbitrage opportunity is available. For no arbitrage to occur the following equation must hold:

$$(1 + Z_{0v2})^2 = (1 + Z_{0v1}) \times (1 + F_{1v2})$$

This equation says that the future value of the two-year loan at maturity at the two-year spot rate must equal the proceeds from investing that money for one year at the one-year spot rate reinvested for a further year at the forward rate that applies between years one and two. In the example the values are as follows:

$$1.05^2 = 1.04 \times (1 + F_{1v2})$$

Therefore:

$$F_{1v2} = 6.01\% \text{ p.a.}$$

A similar method will calculate F_{2v3}, the forward interest rate applying between years two and three. Suppose a trader borrows \$1 for three years now at Z_{0v3} and invests the \$1 for two years at Z_{0v2}. For no arbitrage to be available the forward rate between years two and three must be such that the following equation is satisfied:

$$(1 + Z_{0v3})^3 = (1 + Z_{0v2})^2 \times (1 + F_{2v3})$$

$$1.06^3 = 1.05^2 \times (1 + F_{2v3})$$

Therefore:

$$F_{2v3} = 8.03\% \text{ p.a.}$$

Notice here that the forward rates are increasing with time. This is the typical situation where the term structure of interest rates shows the spot rates increasing with time to maturity. The market is building in expectations of rising interest rates in the future.

FORWARD RATES AND FRAs

Forward interest rates must relate to the market prices of forward rate agreements and interest rate futures, otherwise arbitrage opportunities may be available. (These products are discussed in Chapters 3 and 5.) This is because futures and FRAs can be used to lock into borrowing or lending rates for future time periods.

For example, suppose a trader could arrange the following deals (this ignores the effects of transaction costs):

- Borrow \$100 000 for two years at the two-year spot rate 5% p.a.
- Deposit \$100 000 for one year at the one-year spot rate 4% p.a.
- Sell a 1v2 year FRA on a notional \$104 000 at a forward rate of 8% p.a.

When the deposit matures in one year it will be worth \$104 000. The trader will reinvest the proceeds for a further year at whatever the prevailing rate of interest happens to be at that point. Table A.3 shows the results of this strategy, taking a range of possible market rates for reinvesting the \$104 000 at the end of year one.

No arbitrage values

The values in column (6) are always positive, whatever happens to interest rates in the future, which shows that there is an arbitrage here. It should not be possible to sell the 1v2 year FRA at 8% p.a. The fair rate for selling the FRA is the forward rate F_{1v2} which was calculated in

Table A.3 Arbitrage constructed if FRA rate is not set at the forward rate

(1) Loan repayment end-year 2 (\$)	(2) Deposit proceeds end-year 1 (\$)	(3) Reinvestment rate at end-year 1 (% p.a.)	(4) Deposit proceeds end-year 2 (\$)	(5) FRA payment end-year 2 (\$)	(6) Net cash end-year 2 (\$)
−110 250	104 000	4	108 160	4160	2070
−110 250	104 000	6	110 240	2080	2070
−110 250	104 000	8	112 320	0	2070
−110 250	104 000	10	114 400	−2080	2070
−110 250	104 000	12	116 480	−4160	2070

The columns in Table A.3 are as follows.
Column (1) is the principal plus interest payable on the initial \$100 000 loan at maturity in two years at a rate of 5% p.a.
Column (2) is the proceeds from depositing the \$100 000 for one year at 4% p.a.
Column (3) has a number of possible levels the one-year rate could take in one year for reinvesting the proceeds of the first deposit.
Column (4) calculates the proceeds of the deposit reinvested for a further year at the rate in column (3).
Column (5) is the payment on the FRA, positive or negative. For example, suppose the one-year interest rate in one year is 4%. The FRA rate is assumed to be 8% and the notional \$104 000. The trader will receive a settlement sum on the FRA of 8% − 4% = 4% applied to the FRA notional, which comes to \$4160.
Column (6) is the sum of columns (1), (4) and (5).

Table A.4 No arbitrage constructed if FRA rate is set at the forward rate

(1) Loan repayment end-year 2 ($)	(2) Deposit proceeds end-year 1 ($)	(3) Reinvestment rate at end-year 1 (% p.a.)	(4) Deposit proceeds end-year 2 ($)	(5) FRA payment end-year 2 ($)	(6) Net cash end-year 2 ($)
−110 250	104 000	4	108 160	2090	0
−110 250	104 000	6	110 240	10	0
−110 250	104 000	8	112 320	−2070	0
−110 250	104 000	10	114 400	−4150	0
−110 250	104 000	12	116 480	−6230	0

the previous section as 6.01% p.a. Table A.4 assumes that the FRA is sold at 6.01% p.a., and the arbitrage profit disappears.

DISCOUNT FACTORS (DFs)

It is often helpful to use **discount factors** when pricing products such as interest rate swaps. A discount factor is the present value of $1 at the zero-coupon or spot rate to the receipt of that cash flow. Table A.5 shows the spot rates used in previous sections of this Appendix and the discount factors that can be derived from these spot rates.

In Table A.5 the one-year spot rate is 4% p.a. The one-year discount factor at this rate is calculated as follows:

$$DF_{0v1} = \frac{1}{1.04} = 0.96153846$$

The two-year spot rate is 5% p.a. So the two-year discount factor at this rate is calculated as follows:

$$DF_{0v2} = \frac{1}{1.05^2} = 0.90702948$$

One advantage of using discount factors is that the present value of a future cash flow can immediately be established by multiplying that cash flow by the discount factor for that time period.

Summary of term structure values

Table A.6 summarizes all the spot rates, discount factors and forward rates developed so far in this and the previous sections. In the next section these values are used to price a fixed-floating interest rate swap.

Table A.5 Spot rates and discount factors

Spot rate	Value (% p.a.)	Discount factor	Value
Z_{0v1}	4.00	DF_{0v1}	0.96153846
Z_{0v2}	5.00	DF_{0v2}	0.90702948
Z_{0v3}	6.00	DF_{0v3}	0.83961928

Table A.6 Summary of spot rates, discount factors and forward rates

Spot rate	Value (% p.a.)	Discount factor	Value	Forward rate	Value (% p.a.)
Z_{0v1}	4.00	DF_{0v1}	0.96153846		
Z_{0v2}	5.00	DF_{0v2}	0.90702948	F_{1v2}	6.01
Z_{0v3}	6.00	DF_{0v3}	0.83961928	F_{2v3}	8.03

PRICING A SWAP FROM THE TERM STRUCTURE

As discussed in Chapter 6, an interest rate swap (IRS) is an agreement between two parties to exchange cash flows on regular dates, in which the cash flows are calculated on a different basis. In a standard single-currency IRS, one payment leg is based on a fixed interest rate and the other is based on a floating or variable rate linked to a benchmark such as the London Interbank Offered Rate (LIBOR). The floating rate is reset at regular intervals, such as every six months. The notional principal used to calculate the payments is fixed.

Suppose a dealer is considering entering into a three-year interest rate swap deal. The details are as follows:

- Notional principal = $100 million
- Swap maturity = 3 years
- Dealer pays fixed rate and receives floating rate annually in arrears.
- Interest calculations are based on annually compounded rates.
- First floating rate setting = 4% p.a. (i.e. based on the spot rate Z_{0v1}).

Under the terms of the swap, the dealer pays a fixed rate on a notional principal of $100 million annually in arrears for three years. The counterparty pays in return a variable rate of interest on $100 million annually in arrears for three years. The question is: What fixed rate of interest should the dealer pay to make this a fair deal? In this case the relevant interest rates and discount factors for the period covered by the IRS are as set out in Table A.6. With this information, the fixed rate can be established by taking the following steps.

Step 1: Calculate the floating cash flows

The first step is to calculate the floating rate cash flows on the swap. These are set out in Table A.7. Since the dealer is receiving the floating rate, these are positive cash flows. The first cash flow due at the end of Year 1 is based on the one-year spot rate of 4% p.a. The second cash flow will be based on the one-year rate in one year's time, which it is assumed is established by the forward rate F_{1v2}. The third and final cash flow will be based on the one-year rate in two years' time, which it is assumed is established by the forward rate F_{2v3}.

Table A.7 Swap floating rate cash flows

Year	Notional ($m)	Rate	Value (% p.a.)	Floating cash flow ($m)
1	100	Z_{0v1}	4.00	4.00
2	100	F_{1v2}	6.01	6.01
3	100	F_{2v3}	8.03	8.03

Table A.8 Present value of floating rate cash flows

Year	Floating cash flow ($m)	Discount factor	Present value ($m)
1	4.00	0.96153846	3.85
2	6.01	0.90702948	5.45
3	8.03	0.83961928	6.74
		Total =	16.04

Step 2: Discount the floating cash flows

The next step is to discount these cash flows at the zero-coupon or spot rates for each time period – or, to make the calculation easier, to multiply each cash flow by the relevant discount factor for that time period. The results and the sum of the present values are shown in Table A.8.

Step 3: Calculate the fixed rate and the fixed cash flows

A par swap is one in which the present values of the floating and fixed legs sum to zero. If a swap is entered into at exactly par the expected payout to both sides is zero and neither side pays a premium to the other. The fixed rate on a par swap is the single rate such that, if the fixed cash flows are calculated at that rate, the present values of the fixed and floating cash flows offset each other. As a result, the swap net present value is zero.

In the example, assuming the swap is agreed at par, the dealer needs to find a fixed rate such that the present value of the fixed cash flows on the swap equals minus $16.04 million. At that rate the net present value – i.e. the sum of the PVs of the fixed and floating cash flows – is zero. A direct way to calculate the rate is shown below, but it can also be found by trial and error. Either way, as Table A.9 shows, the answer is 5.92% p.a. The fixed cash flows are minus $5.92 million each year for three years. The present values are established by multiplying each cash flow by the appropriate discount factor. The sum of the present values is minus $16.04 million, which offsets the present value of the floating leg cash flows. (There is some rounding in these values.)

Direction calculation of swap rate

The fair fixed rate for the IRS can be found by using the forward rates and discount factors. It is a weighted average of the spot rate Z_{0v1} and the forward rates F_{1v2} and F_{2v3} weighted by

Table A.9 Present value of fixed rate cash flows

Year	Notional ($m)	Fixed cash flow ($m)	Discount factor	Present value ($m)
1	100	−5.92	0.96153846	−5.69
2	100	−5.92	0.90702948	−5.37
3	100	−5.92	0.83961928	−4.97
			Total =	−16.04

discount factors DF_{0v1}, DF_{0v2} and DF_{0v3} respectively.

$$\frac{(0.04 \times 0.96153846) + (0.0601 \times 0.90702948) + (0.0803 \times 0.83961928)}{0.96153846 + 0.90702948 + 0.83961928} = 0.0592 = 5.92\%$$

CALCULATING THE BINOMIAL VALUES

In the binomial tree developed in Chapter 13 the **option delta** (otherwise known as the hedge ratio) is 0.5 or one-half. The 0.5 value means that if a trader writes a call on a certain number of shares (such as 100) he or she will have to buy half that number of shares (50 in the example) to neutralize the exposure to movements in the underlying stock price. This is called a **delta hedge** and the resulting position is called a delta-neutral position.

The option delta (Δ) can be calculated as follows. It measures the sensitivity of the option value to a given change in the value of the underlying share:

$$\Delta = \frac{C_u - C_d}{S_u - S_d}$$

where:

C_u = value of the call if the share price goes up
C_d = value of the call if the share price goes down
S_u = value of the share when it moves up
S_d = value of the share when it moves down.

Taking the example in Chapter 13 (the values here are per share):

$$\Delta = \frac{25 - 0}{125 - 75} = 0.5$$

Next, let C be the option value at time zero. It can be calculated by taking the following steps.

Let:

$$p = \frac{1 - d}{u - d}$$

where:

d = the factor that moves the share price down from its spot price in the binomial tree. In the example $d = 0.75$. In other words, \$75 is \$100 times 0.75.
u = the factor that moves the share price up from its spot price in the binomial tree. In the example $u = 1.25$. In other words, \$125 is \$100 times 1.25.

So in the example:

$$p = \frac{1 - 0.75}{1.25 - 0.75} = 0.5$$

The call value per share C is given by the following equation:

$$C = (p \times C_u) + [(1 - p) \times C_d]$$

where:

C_u = value of the call at time one if the share price rises
C_d = value of the call at time one if the share price falls.

In the example:

$$C = (0.5 \times 25) + (0.5 \times 0) = \$12.50$$

Option value as a weighted average payout

This formula for calculating the call value C in the previous subsection is actually a type of weighted average payout calculation, but one that is based on the idea that the risk on the option position can be fully hedged.

Under this special assumption the 'probability' of the share price rising to \$125 at expiry and the intrinsic value of the call being \$25 per share is 0.5 or 50%. The probability of the share price falling to \$75 and the intrinsic value being zero is also 50%. The average of the two payouts weighted by the 'probability' of achieving each payout is used to calculate the value of the call at time zero.

These pseudo-probabilities apply in a so-called risk-neutral world in which the risk on the option can be exactly matched by creating a delta hedge portfolio. They are not to be confused with an analyst's subjective estimate of what the share price is likely to be in the future.

Positive interest rates

In real cases interest rates are unlikely to be zero. With positive interest rates the values p and C in the one-step binomial tree described in Chapter 13 can be recalculated as follows:

$$p = \frac{(1+r) - d}{u - d}$$

$$C = \frac{(p \times C_u) + [(1-p) \times C_d]}{1+r}$$

where r is the simple interest rate for one time period as a decimal (e.g. 10% will be 0.1).

Note that if interest rates are positive the forward or expected value of a non-dividend paying stock in the future is higher than the spot price (see Chapter 2). In the binomial model this will mean that the 'probability' p of the stock moving up from the spot price is higher than the 'probability' $1 - p$ of it taking a step downwards.

BLACK-SCHOLES MODEL

As the number of binomial steps is increased the call value will converge on the result produced by the famous **Black-Scholes** model. The model was developed by Black, Scholes and Merton in the 1970s and is a vital tool in modern finance. For European options with no dividends Black-Scholes gives the following values. This version uses continuously compounded interest rates:

$$C = [S \times N(d_1)] - [E \times e^{-rt} \times N(d_2)]$$

$$P = [E \times e^{-rt} \times N(-d_2)] - [S \times N(-d_1)]$$

where:

$$d_1 = \frac{\ln\left(\frac{S}{E}\right) + (r \times t) + \left(\sigma^2 \times \frac{t}{2}\right)}{\sigma \times \sqrt{t}}$$

$$d_2 = d_1 - (\sigma \times \sqrt{t})$$

where:

C = call value
P = put value
S = spot price of the underlying
E = strike price of the option
$N(d)$ = cumulative normal density function. The Excel function to use is NORMSDIST()
$\ln(x)$ = natural logarithm of x to base e. The Excel function to use is LN()
σ = volatility p.a. of the underlying asset (as a decimal)
t = time to expiry of the option (in years)
r = continuously compounded interest rate p.a. (as a decimal)
$e \approx 2.71828$, the base of natural logarithms. The Excel function to calculate e^x is EXP(x).

The formula for a call says that the call value C is the spot price (S) minus the present value of the strike (E), where S and E are weighted by the risk factors $N(d_1)$ and $N(d_2)$.

Like the binomial approach, the formula is based on the assumption that options can be delta-hedged in a riskless manner by trading in the underlying and by borrowing and lending funds at the risk-free rate. It assumes that the returns on the underlying asset follow a normal distribution. Under such specific assumptions, the factor $N(d_2)$ measures the probability that the call will expire in-the-money and be exercised. The factor $N(d_1)$ is the option delta, the hedge ratio.

Generally, the function $N(d)$ calculates the area to the left of d under a normal distribution curve with mean 0 and variance 1. That is, it calculates the probability that a variable with a standard normal distribution will be less than d.

BLACK-SCHOLES EXAMPLE

The task is to price a European call using the following data.

- Underlying cash price $S = 300$
- Exercise price $E = 250$
- Risk-free rate $r = 10\%$ p.a. (0.1 as a decimal)
- Time to maturity $t = 0.25$ years
- Volatility $\sigma = 40\%$ p.a. (0.4 as a decimal).

The Black-Scholes formula gives the following value.

$$C = [300 \times 0.8721] - [250 \times e^{-0.1 \times 0.25} \times 0.8255] = 60.36$$

where:

$$d_1 = \frac{\ln\left(\frac{300}{250}\right) + (0.1 \times 0.25) + \left(0.4^2 \times \frac{0.25}{2}\right)}{0.4 \times \sqrt{0.25}} = 1.1366$$

$$d_2 = 1.1366 - (0.4 \times \sqrt{0.25}) = 0.9366$$

$$N(d_1) = 0.8721$$

$$N(d_2) = 0.8255$$

The risk-neutral probability of exercise in this case is 82.55%, since the option is quite deeply in-the-money.

BLACK-SCHOLES WITH DIVIDENDS

The model can be adjusted to price European options on assets paying dividends. The following version assumes that dividends are paid out in a continuous stream and is commonly used to price index options.

If q is the continuous dividend yield then:

$$C = [S \times e^{-qt} \times N(d_1)] - [E \times e^{-rt} \times N(d_2)]$$

where:

$$d_1 = \frac{\ln\left(\frac{S}{E}\right) + [(r - q) \times t] + \left(\sigma^2 \times \frac{t}{2}\right)}{\sigma \times \sqrt{t}}$$

$$d_2 = d_1 - (\sigma \times \sqrt{t})$$

In the case of an individual share it is not quite realistic to assume that dividends are paid in a constant stream. One common approach is to use Black-Scholes but to replace the spot price with the spot price minus the present value of the expected dividends over the life of the option. These are discounted at the risk-free rate.

MEASURING HISTORIC VOLATILITY

In the options market historic volatility is commonly measured as the **standard deviation** of the returns on the underlying asset over some historical period of time. It is normally annualized. The percentage returns are calculated by taking the natural logarithms of the price relatives rather than simple percentage price changes.

The Excel function that calculates the natural log of a number is LN(). It is the inverse of the EXP() function. Using natural logs has very useful consequences. For example, suppose that a share is trading at 500 and the price rises to 510. The **price relative** is the new share price divided by the old price:

$$\frac{510}{500} = 1.02$$

The simple percentage price change is:

$$\frac{510}{500} - 1 = 2\%$$

But suppose then that the share price falls back again to 500. The simple percentage fall in price is:

$$\frac{500}{510} - 1 = -1.96\%$$

The problem is that these simple percentage changes cannot be added together. If the share price starts at 500 and ends at 500 then the overall change in the share price is actually zero, not 0.04%. Using natural logarithms cures this problem:

$$\ln\left(\frac{510}{500}\right) + \ln\left(\frac{500}{510}\right) = 0$$

Daily volatility calculation

Table A.10 illustrates the first stages in the calculation of historic volatility using natural logarithms.

In Table A.10 the price of the underlying security starts at 500 on day zero. Column (2) shows the closing price of the share over the next 10 trading days (two calendar weeks). Column (3) calculates the natural logarithm of the price relatives. For example, the percentage change in the share price between days 0 and 1 is as follows:

$$\ln\left(\frac{508}{500}\right) = 1.59\%$$

The **average daily percentage change** in the share price is 0.22%. Column (4) calculates the extent to which each daily percentage price change deviates from the average. For instance, 1.59% is 1.37% above the average. Column (5) squares the deviations.

Sample variance is a statistical measure of the extent to which a set of observations in a sample diverges from the average value. Table A.10 has 10 observations based on the change

Table A.10 First stages in calculation of historic volatility

(1) Day	(2) Price	(3) Price change	(4) Deviation	(5) Deviation^2
0	500			
1	508	1.59%	1.37%	0.02%
2	492	−3.20%	−3.42%	0.12%
3	498	1.21%	0.99%	0.01%
4	489	−1.82%	−2.04%	0.04%
5	502	2.62%	2.41%	0.06%
6	507	0.99%	0.77%	0.01%
7	500	−1.39%	−1.61%	0.03%
8	502	0.40%	0.18%	0.00%
9	499	−0.60%	−0.82%	0.01%
10	511	2.38%	2.16%	0.05%
	Average =	0.22%	Sum =	0.33%

in the share price over two calendar weeks. The sample variance is calculated as follows:

$$\text{Variance } \sigma^2 = \frac{\text{Sum of squared deviations}}{\text{Number of observations} - 1}$$

$$\text{Variance } \sigma^2 = \frac{0.33\%}{10 - 1} = \frac{0.0033}{9} = 0.000367 = 0.0367\%$$

The reason for dividing by one less than the number of observations is simply to adjust for the fact that the calculation is based on a sample of price changes. (Some analysts prefer not to make this adjustment.)

Volatility is defined as the standard deviation of the returns on the share. It is the square root of the variance.

$$\text{Standard Deviation } \sigma = \sqrt{\text{Variance}} = \sqrt{0.000367} = 0.0192 = 1.92\%$$

Annualizing volatility

Here 1.92% is the **daily volatility** of the returns on the share. It was based on the average daily percentage price change over a series of trading days and measures dispersion around that daily average value.

Volatility is normally expressed on an annualized basis in the options market. If there are 252 trading days in the year then the annualized volatility is the daily volatility times the square root of 252.

$$\text{Annual volatility} = 1.92\% \times \sqrt{252} = 30.4\%$$

Intuitively, the 'square root rule' used here to annualize volatility is based on the idea that short-term fluctuations in the prices of securities tend to smooth out to some extent over a longer period of time. Annual volatility is therefore far less than daily volatility times the number of trading days in the year.

Note that this may be a reasonable assumption to make in normal market conditions when shares are following something close to a 'random walk' and there is no statistical relationship between the previous movement in the share price and the next movement. In extreme circumstances such as stock market crashes these conditions may well not apply.

Appendix B
Exotic Options

The term 'exotic option' is a rather loose one, but it is conventionally used to describe later generation options whose terms differ in some way from the standard terms of a vanilla call or put option. This Appendix describes briefly some of the key structures used in the markets.

Asian or average price options

The payoff from an average price call is zero or the average price of the underlying over a predetermined period of time minus the strike, whichever is the greater. The payoff from an average price put is zero or the strike minus the average price of the underlying over a set period of time, whichever is the greater.

Asian options are generally less expensive than conventional options since averaging prices over a period of time has the effect of lowering volatility. The more frequently the averaging is carried out the greater this effect, so that daily averaging reduces volatility more than weekly or monthly averaging. For the same reason geometric averaging reduces volatility more than arithmetic averaging.

A further variant is the **average strike** option. Here the price of the underlying over some period of time is averaged out and the strike price is set to that average. The payout of an average strike call is zero or the difference between the price of the underlying and the strike on exercise, whichever is the greater.

Barrier options

The payoff from a barrier option depends on whether or not the price of the underlying reaches a certain level during a specified period of time or during the whole life of the option.

Barriers are either **knock-in** or **knock-out** options. A knock-in comes into existence only if the underlying price hits a barrier (sometimes called the in-strike). A knock-out ceases to exist if the underlying price reaches a barrier (sometimes called the out-strike). Sometimes the buyer receives a pre-set rebate if the option is knocked out or fails to be knocked in. With call options there are four possibilities:

- **Down-and-in call**: comes into existence if the underlying price falls to hit the barrier.
- **Up-and-in call**: comes into existence if the underlying price rises to hit the barrier.
- **Down-and-out call**: ceases to exist if the underlying price falls to hit the barrier.
- **Up-and-out call**: ceases to exist if the underlying price rises to hit the barrier.

The same possibilities exist with puts. For example, an up-and-out put ceases to exist if the underlying price rises and hits a barrier above the current spot price. It will be less expensive than a standard put option and when used to protect against falls in the value of the underlying will provide cheaper protection than a vanilla option. However the 'insurance' will cease to exist if the underlying price rises to hit the out-strike.

Bermudan options

With an American option the holder can exercise at any time during the life of the option. With a Bermudan option the holder may only exercise at agreed times during the life of the option. Bermudan options provide more flexibility than European options because of the possibility of early exercise but are normally cheaper than standard American-style contracts.

Binary (digital) options

Binary options pay out a sum of money if they expire in-the-money, or otherwise nothing at all. For example, a **cash-or-nothing** call pays out a fixed amount of cash if the price of the underlying is above the strike at expiry, otherwise it expires worthless. Another variant is the **asset-or-nothing** call. This pays out an amount equal to the value of the underlying asset if it expires in-the-money, otherwise it pays nothing.

Chooser (preference) options

With a chooser or 'U-choose' option the holder can choose whether the option is a call or a put at a specified point in time. Normally the call or put will have the same time to expiry and strike price, although more complex structures have been assembled where this is not the case.

A trader or investor might buy chooser options when he or she believes that the underlying asset will be subject to price volatility but is uncertain whether the price will go up or down.

Compound options

These are options on options. There are four main types:

- a call on a call;
- a put on a call;
- a call on a put;
- a put on a put.

In the case of a call on a call the buyer has to pay a premium up-front for the option to buy a call option. If the holder exercises that compound option then he or she receives the underlying call and pays in return a further premium. The underlying call will normally have standard terms: it will be an American or European-style option with a fixed expiry date and a fixed exercise price.

Exchange options

Exchange options are options to exchange two assets – for example, one share for another, or one foreign currency for another. Effectively, a convertible bond is an exchange option since the holder has the right but not the obligation to exchange a fixed coupon bond for shares or (sometimes) for another type of debt.

Forward-start options

Forward-start options are paid for now but start at some future date. Normally it is agreed that the strike will be set at-the-money on the start date.

Cliquet

A cliquet or ratchet option consists of a standard at-the-money option followed by a strip of forward-start options whose strike will be set at-the-money on the forward start date.

For example, a cliquet option might consist of a one-year at-the-money spot-start call option followed by a strip of two forward-start at-the-money call options each with one year to expiry. Suppose the underlying spot price at the outset is \$100. If at the end of year one the underlying is trading at \$110 the holder makes \$10 on the one-year spot-start call. The strike for the next option in the strip is set at-the-money at \$110.

If at the end of year two the underlying is trading at \$115 the holder makes a further \$5 profit. The strike for the final call in the strip is set at \$115. If at the end of year three the underlying is back trading at \$100 then the final option expires worthless. However the holder has locked in the interim \$15 gains.

Ladder options

Ladders are similar to cliquets in that the holder can lock in profits made during the life of the contract. At expiry a **fixed strike** ladder call pays the difference between the highest of a series of threshold prices or 'rungs' reached by the underlying and the strike, or zero if no rung is reached.

In a **floating strike ladder** option the initial strike is reset whenever the underlying price hits a prescribed 'rung' in the ladder rather than (as is the case with a cliquet) on specific dates. For example, consider a ladder call with the initial strike set at-the-money at \$100 and rungs set at \$10 intervals above that level. If the underlying hits \$110 at any point the strike is reset to \$110 and the \$10 profit is locked in. If the underlying subsequently reaches \$120 a further gain of \$10 is achieved and the strike is again reset, this time to \$120.

Lookback options

The payoff from a lookback option depends on the maximum or minimum price of the underlying asset during the life of the option.

In a **floating strike** lookback call the strike is the minimum price achieved by the underlying during the life of the option. Its payoff is the extent to which the asset price at expiry exceeds that strike. It is a way of buying the underlying at the lowest price it trades at during the life of the option.

In a floating strike lookback put the strike price is the maximum price of the underlying during the life of the option. Its payoff is the extent to which that strike exceeds the underlying price at expiry. It is a way of selling the underlying at the highest price it achieves during the life of the option.

The payoff from a **fixed strike** lookback call option at expiry is the extent to which the highest price achieved by the underlying over the life of the option exceeds the strike. Lookback options are normally more expensive than conventional call and put options.

Multi-asset options

The payoff from a multi-asset option depends on the values of two or more underlying assets. A simple example is a basket option whose payoff is typically determined by the weighted average value of a portfolio of underlying assets. Another example is a **best of** call whose payoff depends on the highest price achieved by two or more underlying assets. By contrast the payoff on a spread or **outperformance** option depends on the difference between the prices of two assets.

Quanto option

The payoff depends on an underlying denominated in one currency, but it is paid in another currency. An example is a call option based on the performance of a basket of UK shares that is payable in US dollars at a predetermined exchange rate. Quantos are attractive for international investors who wish to buy assets that are denominated in a foreign currency but who do not wish to take the exchange rate risk.

Shout option

These are similar to cliquets and ladders except that the strike is reset by the holder rather than at predetermined times or price levels. For example, if the initial strike is $100 and the asset price reaches $120 the holder can 'shout' and lock in a gain of $20. The strike will be reset at $120. The total gain at expiration will be $20 plus any intrinsic value on a call with a strike set at $120.

Appendix C
Glossary of Terms

Accreting swap A swap in which the principal increases in each time period.
Accrued interest Interest on a bond or swap that has accrued since the last coupon date.
American option An option that can be exercised on any business day during its life.
Amortization Repayment of the principal on a loan or bond in instalments over a period of time.
Amortizing swap A swap in which the principal is reduced in each time period.
Arbitrage A set of transactions in which risk-free profits are achieved because assets are mispriced in the market. More loosely, a strategy that is not entirely risk-free but generates profits in most circumstances.
Arbitrageur Someone who takes advantage of arbitrage opportunities.
Asian or Asiatic option Another name for an average price option.
Ask The offer or sale price of an asset or derivative contract.
Asset A physical commodity or a financial asset such as a share or a bond.
Asset-backed securities Bonds backed by a pool of assets such as mortgages and credit card loans. The cash flows from the assets are used to repay the bondholders.
Asset-or-nothing (AON) option An option that pays out an amount equal to the price of the underlying if it expires in-the-money, otherwise nothing.
Assignment Formal notification from an exchange that the writer of a call (put) option must deliver (take delivery of) the underlying asset at the exercise price.
As-you-like option *See*: Chooser option.
At-best order An order to a broker to buy or sell a contract at the best price available.
At-the-money option An option whose strike is equal to the price of the underlying. Its intrinsic value is zero.
Average price (or rate) option The payout on a fixed strike contract is based on the difference between the strike and the average price of the underlying during a specified period. In a floating strike contract the strike is based on the average price of the underlying during a specified period, and the payout is based on the difference between this and the price of the underlying on exercise.
Back office The part of a securities or derivatives business that settles and keeps account of the trades carried out by the traders in the 'front office'.
Backwardation When the forward price of an asset is below the spot price. *See*: Contango.
Bank for International Settlements (BIS) The BIS acts to promote international cooperation in financial matters.
Barrier option An option whose payoff depends on whether the underlying has hit one or more threshold or barrier levels.
Basis The difference between the spot price of an asset and the futures price. When the futures price is above the cash price the basis is negative. This represents the negative cost of carrying a position in the asset to deliver on the future date. When the futures price is below the spot price the basis is positive.

Basis point In the money markets one basis point equals 0.01% p.a.

Basis risk Specifically, the risk that arises because futures prices do not exactly track changes in the price of the underlying asset, because of changes in the basis. This poses problems for those using futures to hedge positions in the underlying. More generally, the risk that results from potential changes in the relationship or 'basis' between two financial variables.

Basis swap Both legs are based on floating interest rates but each is calculated on a different basis. For example, one leg might be based on the return on commercial paper and the other based on LIBOR.

Basket option The payoff depends on the performance of a basket or portfolio of assets.

Bear Someone who thinks that a security or sector or market will fall in price.

Bear spread A combination option strategy with a limited loss if the price of the underlying rises and a limited profit if it falls.

Bermudan option Can be exercised on specific dates up to expiry, such as one day per month.

Beta A measure of the systematic or undiversifiable risk of a security or portfolio. Securities with betas higher than one are more risky than the market as a whole, and their required returns are higher.

Bid The price a dealer is prepared to pay for a security or a derivative.

Bid/offer spread The difference between the bid price of an asset or derivative contract and its offer or ask or sale price.

Big figure In the FX markets, the first decimal places of a currency rate quotation.

Binary or digital option *See*: Cash-or-nothing option; Asset-or-nothing option.

Binomial tree A set of prices developed from the spot price of the underlying, such that at any 'node' in the tree the asset can either move up or down in price by a set amount. Used to price options and convertible bonds.

Black model A variant on the Black-Scholes model, used to price European options on forwards and futures.

Black-Scholes model The European option pricing model developed by Black, Scholes and Merton in the 1970s.

Blue chip A share issued by a top-name company that may be considered to provide a consistent return.

Bond A debt security issued by a company, a sovereign state and its agencies, or a supranational body. A straight or 'plain vanilla' bond pays a fixed coupon (interest amount) on regular dates and the par or face value is paid at maturity.

Bond option A call or put option on a bond.

Bond rating An assessment of the credit or default risk on a bond issued by an agency such as Moody's or Standard & Poor's.

Bootstrapping Deriving zero-coupon or spot rates from the prices of coupon bonds or from the par swap curve.

British Bankers' Association (BBA) Calculates LIBOR rates each business day for a range of currencies.

Broker A person or firm paid a fee or commission to act as an agent in arranging purchases or sales of securities or derivative contracts.

Bull Someone who thinks that a particular asset or market will increase in price.

Bull spread A combination option strategy with a limited profit if the underlying increases in price but a limited loss if it falls.

Bund Treasury bond issued by the Federal German government.

Butterfly A long butterfly is a combination option strategy produced by buying a call, selling two calls with a higher strike, and buying a call struck further above that level. All the options are on the same underlying and with the same expiry. It can also be assembled using put options.

Buy-Write *See*: Covered call.

Calendar or time spread A strategy that involves buying and selling options on the same underlying with different expiry dates to exploit differences in time value decay.

Call feature A feature that allows the issuer of a bond to redeem the bond before maturity.

Call option The right but not the obligation to buy an underlying asset at a fixed strike price.

Capital adequacy A system under which banks are obliged to maintain a required ratio of capital in proportion to assets such as loans. Assets are weighted according to their risk.

Caplet One component of an interest rate cap.

Capped floating rate note (FRN) The rate of interest on the note cannot exceed a given level.

Cash-and-carry arbitrage Selling over-priced futures contracts and buying the underlying to achieve a risk-free profit. Or buying under-priced futures and shorting the underlying.

Cash flow waterfall The system of payments in a CDO structure. The tranches are paid in sequence out of the cash flows from the collateral, from the highest to the lowest ranking, with the equity tranche paid last. *See*: Collateralized debt obligation.

Cash-or-nothing (CON) option Pays out a fixed amount of cash if it expires in-the-money, otherwise nothing.

Cash security An underlying security such as a share or a bond rather than a derivative.

Cash settlement Settling a derivative contract in cash rather than through the physical delivery of the underlying asset.

Cat bond Catastrophe bond. Pays a high coupon but investors risk losing their capital if the losses to insurers on certain ‘catastrophic’ events such as hurricanes exceed certain levels.

CDD index Used in weather derivatives to measure the extent to which summer weather is unusually warm.

Cheapest-to-deliver bond (CTD) The bond that is the cheapest to deliver against a short position in a bond futures contract.

Chicago Board Options Exchange (CBOE) The major options exchange founded in 1973.

Chicago Board of Trade (CBOT) Started as a commodity market in the nineteenth century and has now developed major financial futures and options contracts, e. g. on US Treasury bonds. Now part of CME Group.

Chicago Mercantile Exchange (CME) The Chicago futures and options exchange where the key Eurodollar futures contract trades. Part of CME Group.

Chooser option The holder can decide at a preset time whether it is a call or a put option. Also known as a U-Choose, as-you-like, call-or-put option.

Circuit breaker Used in some exchanges to stop trading when the market moves through a trigger level.

Clean price The price of a bond excluding interest accrued since the last coupon date.

Clearing house The organization that registers, matches, monitors and guarantees trades made on a futures and options exchange. Nowadays may also guarantee the performance of over-the-counter derivatives trades.

Clearing member Not all members of a futures and options exchange are clearing members. All trades must eventually be settled through a clearing member which deals directly with the clearing house.

Cliquet (ratchet) option The strike is reset on specific dates according to the spot price of the underlying, locking in interim gains.

Collared floating rate note Has a minimum and a maximum coupon rate.

Collateral Cash or securities pledged against the performance of some obligation.

Collateralized debt obligation (CDO) A debt security issued by a special purpose vehicle (SPV) which is repaid from the cash flows generated by a portfolio of assets such as bonds or loans, also known as the collateral. Normally different classes or tranches of CDOs are issued with different risk and return characteristics. Depending on the nature of the underlying assets in the pool a CDO may be called a Collateralized Loan Obligation (CLO) or a Collateralized Bond Obligation (CBO). *See*: Special purpose vehicle (SPV).

Combination strategy A strategy involving a mixture of options.

Commercial bank A bank that makes loans to corporations or governments.

Commission The fee charged by a broker to a customer for completing a purchase or sale.

Commodity A physical item such as oil, gold or grain. Commodities are traded for spot and for future delivery.

Commodity swap At least one of the payment legs depends on the price of a commodity.

Common stock Securities which provide a share in the net income of a business, after payments have been made to the debt holders and on any preferred stock. Common stockholders have a residual claim on the firm's assets in the event of liquidation. They normally have voting rights. Known in the UK as ordinary shares.

Compound option An option to buy or sell an option.

Contango When the forward price of an asset is higher than the spot price. *See*: Backwardation.

Contingent capital securities (CoCos) Debt securities issued by a bank that convert into equity (or preferred stock) in extreme circumstances when it would face difficulties in raising additional capital. They were first issued in November 2009 by Lloyds Banking Group (under the name Enhanced Capital Notes or ECNs). These convert into equity (ordinary shares or common stock) if the bank's capital ratio falls below a threshold level.

Continuously compounded rate A method of quoting interest rates commonly used in the derivatives markets.

Contract size The unit of trading on a derivative contract. For example, the 30-year Treasury bond futures contract on the CBOT is for $100 000 par value US Treasury bonds.

Conversion (price) factor A factor assigned to a bond that is deliverable against a bond futures contract. It adjusts the amount invoiced by the seller to the buyer if that bond is delivered.

Conversion premium Measures how much more expensive it is to buy a share by buying and converting a convertible bond compared to buying the share in the cash market.

Conversion ratio The number of shares a convertible bond can be converted into.

Convertible bond A bond that is convertible (at the option of the holder) into a predetermined number of (normally) shares of the issuing company.

Convexity In the bond market, a measure of the curvature in the relationship between the price of a bond and market interest rates. In the derivatives markets sometimes used to refer to option gamma. *See*: Gamma.

Cost of carry The cost of holding or carrying a position in an asset (funding plus storage and other costs) less any income received on the asset.

Counterparty The other party to a trade or contract.

Counterparty risk The risk that a trading counterparty might fail to fulfil its contractual obligations.

Coupon The periodic interest amount payable on a bond.

Coupon rate The interest rate payable on a bond.

Covered call The purchase of an underlying asset combined with a sale of a call option on that asset.

Covered warrant A longer-dated option on a share or a basket of shares issued by a financial institution which trades in the form of a security. It is normally listed on a stock exchange.

Credit default swap (CDS) A contract in which a protection buyer pays a periodic premium ('spread') to a protection seller. If a credit event such as bankruptcy occurs affecting the reference entity specified in the contract the protection buyer receives a payment from the protection seller. The reference entity can be a corporation, or a financial institution, or a sovereign state. If a credit event occurs some CDSs are settled by the protection buyer delivering a debt asset of the reference entity and receiving the par value from the protection seller. Others are settled in cash.

Credit derivative A derivative whose payoff depends on the credit standing of an organization or group of organizations.

Credit enhancement Methods used to enhance credit quality. For example, in a securitization a common credit enhancement technique involves the creation of subordinated tranches which suffer the first losses arising from default in the asset pool. This allows the senior tranche to achieve a top credit rating. *See*: Securitization.

Credit rating An assessment of the probability that a borrower or an issuer of debt securities will make timely payments on its financial obligations.

Credit risk The risk of default or non payment on a loan or bond or a contractual agreement such as a swap.

Credit spread The additional return on a bond or a loan over some benchmark rate, dependent on the creditworthiness of the borrower. Often it is expressed as a number of basis points over LIBOR or the yield on a government bond.

Credit spread derivative A contract whose payoff depends on the difference between the actual credit spread on two assets in the future and a spread agreed in the contract. The spread could be over LIBOR or a Treasury bond or some other benchmark.

Cross-currency swap An interest rate swap where the payment legs are made in two different currencies.

Currency option The right but not the obligation to exchange one currency for another at a fixed exchange rate. Also known as an FX option.

Currency overlay A strategy used in investment management to divorce decisions made on buying foreign assets from decisions on currency exposures. The manager can hedge the currency risk or take on additional currency exposure.

Currency risk The risk of losses resulting from movements in currency exchange rates.

Currency translation risk The risk that results from translating foreign currency earnings back into its home currency when the consolidated accounts of a company with international operations are prepared.

DAX An index of the 30 largest German companies weighted by market capitalization. It is a total return index – dividends on the shares are assumed to be reinvested.

Day-count The calendar convention applied to a quoted interest rate or yield.

Dealing spread The difference between a trader's bid and ask (offer) price.

Debt Money owed to creditors or lenders or to holders of debt securities.

Debt security A tradable security such as a bond that represents a loan made to the issuer.

Deferred swap A forward-start swap, i.e. one that starts on a future date.

Deliverable obligation A debt asset that can be delivered by the protection buyer to the protection seller in a credit default swap.

Delivery The process of delivering assets. Some derivative contracts involve the physical delivery of the underlying. Others are settled in cash.

Delivery month When a futures contract expires and delivery or final cash settlement takes place.

Delta The change in the value of an option for a small change in the value of the underlying asset.

Delta hedging Protecting against losses on an option or portfolio of options arising from small changes in the price of the underlying.

Delta neutral An option position that is delta hedged and protected against small changes in the price of the underlying asset.

Derivative An instrument whose value depends on the value of an underlying asset such as a share or a bond.

Digital option Also known as a binary option. *See*: Asset-or-nothing option; Cash-or-nothing option.

Dilution The reduction in earnings per share caused by the creation of new shares.

Dirty price The clean price of a bond plus interest accrued since the last coupon payment.

Discount factor The present value of $1 at the spot or zero-coupon rate for a specific time period.

Discount rate Generally, the rate used to discount future cash flows to a present value. In the US money markets, the rate charged to banks when borrowing directly from the Federal Reserve (the US central bank).

Discount security A security such as a Treasury bill that pays no interest but trades below its face or par value.

Dividend A cash payment a company makes to its shareholders.

Dividend yield Dividend per share divided by the current market price of a share.

Dow Jones Industrial Average (DJIA) Price-weighted index based on 30 leading US companies.

Down-and-in option Comes into existence if the price of the underlying falls to hit a barrier level.

Down-and-out option Ceases to exist if the price of the underlying falls to hit a barrier level.

Downside risk The risk of making a loss on a trading position or an investment.

Dual currency bond Pays interest in one currency but is denominated in another currency.

Early exercise Exercising an option before expiry.

Efficient market theory Theory that asset prices reflect currently available information and fully discount expected future cash flows. Criticized by some for ignoring the costs of acquiring and processing information.

Embedded option An option that is embedded in a security such as a convertible bond or a structured financial product. The option cannot be traded separately.

Equity An equity security has a residual claim on the assets of a firm after the debt is paid. *See*: Common stock.

Equity collar Buying a protective put and selling an out-of-the-money call to protect against losses on the underlying whilst reducing (or eliminating) the net premium due. The disadvantage is that profits on the underlying are capped.

Equity swap An agreement between two parties to make regular exchanges of payments where one payment leg is based on the value of a share or a basket of shares. The other leg is normally based on a fixed or a floating interest rate.

Equity tranche In a securitization, the class of securities that takes the first loss if assets in the underlying portfolio suffer from default.

Eurex The merged German-Swiss electronic derivatives exchange.

Euribor Reference rate set in Brussels for interbank lending in euros, the European common currency.

Eurobond A bond denominated in a currency other than that of the country in which it is issued, and marketed to international investors via underwriting banks.

Eurocurrency A currency held on account outside the domestic market and outside the direct control of its regulatory authorities.

Eurocurrency deposit Eurocurrency placed on deposit with a bank.

Eurodollar A dollar held on deposit outside the US.

Eurodollar futures A futures contract traded on Chicago Mercantile Exchange based on the interest rate on a notional three-month Eurodollar deposit for a future time period.

Euromarket The international market for dealings in Eurocurrencies.

European option An option that can only be exercised at expiry.

Exchange An organized market in which securities or derivatives are traded.

Exchange option An option to exchange one asset for another.

Exchange delivery settlement price (EDSP) The price used to settle a futures contract when it expires.

Exchange-traded contract A derivative contract traded on an organized exchange.

Exchangeable bond Exchangeable (at the option of the holder) for a predetermined number of shares of a company other than the issuer of the bond.

Ex-dividend (xd) The buyer of a security trading xd is not entitled to the next dividend. It goes to the seller.

Exercise The action taken by the holder of a call (put) option when he or she takes up the option to buy (sell) the underlying.

Exercise or strike price The price at which the holder of a call (put) option takes up the right to buy (sell) the underlying asset.

Exotic option A nonstandard contract, e. g. a barrier or an average price or a binary option.

Expected value The expected value of an asset on a future date.

Expiry or expiration date The last day of a contract.

Extendable swap A swap which can be extended at the choice of one of the parties to the deal.

Face value The principal or par value of a debt security such as a bond or a Treasury bill, normally paid at maturity.

Fair value The theoretical value of a financial asset, often established using a pricing model.

Fill-or-kill (FOK) An order on an exchange which is either executed in its entirety at the stipulated price or cancelled.

Financial futures An exchange-traded contract in which a commitment is made to deliver a financial asset in the future at a fixed price, or to make a cash settlement payment based on the difference between a fixed price and the price of the underlying asset when the contract expires.

Fixed interest (income) security Literally, a security that pays a fixed coupon on regular dates until maturity. Often though it is used as a generic term for bonds.

Flex option An exchange-traded option that has some flexibility as to its terms, e. g. the strike price can be nonstandard.

Floating rate A rate of interest such as LIBOR that varies over time.

Foreign exchange risk The risk of losses resulting from changes in foreign exchange rates.

Forward contract An agreement between two parties to buy and to sell an asset at a fixed price on a future date, or to make a cash settlement based on the difference between a fixed price and the actual market value of the asset on a future date.

Forward exchange rate The rate to exchange two currencies on a date later than spot.

Forward interest rate (forward-forward rate) The rate of interest that applies between two dates in the future.

Forward rate agreement (FRA) A bilateral contract to make a cash settlement payment based on the difference between a fixed interest rate for a single future time period and the actual market rate set for that period.

Forward-start option An option that starts on a future date.

Forward-start swap A swap that starts on a date later than spot.

FT-SE 100 Index An index of the top 100 UK shares weighted by market capitalization.

Fungible Two securities or derivative contracts are said to be fungible when they can be considered as directly interchangeable.

Futures contract An agreement transacted through an organized exchange to buy and to sell an underlying asset at a fixed price on a future date, or to make a cash settlement based on the difference between a fixed price and the actual market value of the asset on a future date.

Futures option An option to buy or sell a futures contract.

FX (currency) option The right to exchange two currencies at a fixed exchange rate.

Gamma The change in an option's delta for a small change in the price of the underlying.

Gearing (UK) or Leverage (USA) In a trading or investment situation, making an enhanced return through a strategy that requires a relatively small initial outlay of capital.

Gilt (gilt-edged security) A bond issued by the UK government.

Government securities Bills, notes and bonds issued by governments.

Greeks The option sensitivity measures: delta, gamma, theta, vega (or kappa) and rho.

HDD index Used in weather derivatives to measure the extent to which winter weather is unusually cold.

Hedge fund Originally, a fund which takes both long and short positions in securities. Nowadays also used to mean a fund that takes highly leveraged or speculative positions.

Hedge ratio The calculation of how much of the hedge instrument (e. g. futures contracts) has to be traded to cover the risk on the asset that is to be hedged.

Hedging Protecting against potential losses.

Historic volatility The volatility of an asset over some past time period.

Implied volatility The volatility assumption implied in an actual option price.

Index A figure representing the changing value of a basket of assets, e. g. a stock market index.

Index arbitrage Arbitrage trade assembled by buying and selling index futures and underlying shares.

Index credit default swap A CDS which is based on an index representing a basket of names rather than a single reference entity. *See*: Credit default swap.

Index fund or tracker A fund that seeks to track or match the performance of a market index.

Index futures A financial futures contract based on a market index, normally settled in cash.

Index option An option on a market index such as the S&P 500.

Inflation derivative A product used to hedge against or speculate on future inflation rates.

Institutional investor A firm such as a pension fund that invests money in financial assets for its clients.

Instrument A share or a bond or some other tradable security or a derivative contract.

Interest rate cap, floor, collar A cap is an option product typically sold to borrowers, which limits their cost of borrowing. If the interest rate for a given time period covered by the cap is above the strike the buyer receives a settlement payment from the seller. A floor establishes a minimum interest rate level. A borrower who buys a cap and sells a floor establishes an interest rate collar and a maximum and minimum borrowing cost.

Interest rate future An exchange-traded contract based on the interest rate for a period of time starting in the future. The listed equivalent of the forward rate agreement.

Interest rate option An option whose value depends on future interest rates.

Interest rate swap Agreement between two parties to exchange payments on regular dates for a specified time period. In a standard deal one payment is based on a fixed interest rate and the return payment is based on a floating rate, usually LIBOR.

Intermarket spread Strategy consisting of opposing positions in two different index products, e. g. a long position in S&P 500 index futures and a short position in another equity index futures.

International Swaps and Derivatives Association (ISDA) Trade association chartered in 1985 for dealers in over-the-counter derivatives such as swaps, caps, floors, collars and swaptions.

In-the-money option One that has positive intrinsic value.

Intrinsic value For a call the price of the underlying minus the strike, or zero, whichever is greater. For a put the strike less the price of the underlying, or zero, whichever is greater. Intrinsic value is either zero or positive.

Iron butterfly A short straddle combined with a long strangle on the same underlying and with the same time to expiry.

Issuer warrant A warrant (longer-dated option) issued by a company on its own shares.

Kappa Another name for vega.

Knock-out or knock-in level The level of the underlying at which a barrier option ceases to exist or comes into existence. Sometimes known as out-strike and in-strike.

Ladder option With a floating strike contract whenever the underlying hits a 'rung' or threshold price level the strike is reset and gains to that point cannot be lost.

LIBOR London Interbank Offered Rate It is an average based on data provided by a panel of major banks on offer (lending) rates for short-term interbank funds available in the London market. LIBOR is compiled by the British Bankers' Association in conjunction with Reuters and released shortly after 11:00 a. m. London time. There is a separate LIBOR rate for each currency listed by the BBA and for a range of maturities.

LIBOR OIS Spread The difference between three-month LIBOR and the overnight index swap (OIS) rate. *See*: Overnight index swap.

LIFFE The London International Financial Futures and Options Exchange. Part of the NYSE Euronext Group.

Limit order An order from a client to a broker to buy or sell an asset or derivative contract with a maximum purchase price or minimum sale price.

Limit price move Some exchanges only allow price moves within certain limits in the course of a trading session. Trading is stopped if the limit is broken.

Liquidity There is a liquid market in an asset if it is easy to find a buyer or seller without affecting the price to any significant extent.

Liquidity risk The risk that trading in an asset dries up and prices cannot be found or are subject to sharp fluctuations.

Local An independent trader on an exchange.

London Metal Exchange (LME) The market for trading nonferrous metals, including futures and options.

Long position (long) The position of a trader who has bought securities or derivative contracts.

Lookback option The payoff is based on the maximum or minimum price of the underlying over a specified time period.

Maintenance margin A system used on some exchanges. A margin call is received if the balance on a trader's account falls below a threshold level.

Mandatorily convertible or exchangeable bond Must be converted into or exchanged for shares on or by a certain date.

Margin call When a trader on a derivatives exchange receives a call to make an additional margin payment because of an adverse movement in the value of a contract.

Market maker A trader or firm which makes two-way prices – bid and offer prices – on specific securities or derivative contracts.

Market risk Also known as price or rate risk. The risk that results from changes in the market prices of assets such as shares and bonds.

Markit Group Firm which maintains a series of indices including the iTraxx Europe index which is based on the CDS premiums on 125 top European names.

Mark-to-market Revaluing investments based on the current market price.

Money market The market for short-term wholesale deposits and loans (normally up to one year) and for trading short-term securities such as Treasury bills.

Monte Carlo simulation A method of valuing a financial asset or portfolio of assets by setting up a simulation based on random changes to the variables that determine the value of the asset or portfolio.

Mortgage-backed security (MBS) Debt security backed by a pool of mortgages. The mortgage payments are earmarked to pay interest and principal on the security. In a pass-through structure all the investors receive the same pro-rata payments from the mortgage pool. In a collateralized mortgage obligation (CMO) different classes of securities are issued with different payment characteristics.

MSCI indices A family of indices maintained by MSCI Barra used as benchmarks by international investors.

Naked option An option position that is not hedged.

NASDAQ The US electronic screen-based share trading market. It is based on quotes from market makers.

Nearby month A derivative contract with the nearest delivery or expiry date from the date of trading.

Net present value (NPV) The sum of a set of present values.
Nikkei 225 An index based on the price-weighted average of 225 shares traded on the Tokyo Stock Exchange. The Nikkei 300 is weighted by market capitalization.
Nominal interest rate or return The stated rate of interest or return on a loan or debt security. Also used to mean an interest rate or return on investment including inflation. *See*: Real interest rate or return.
Normal distribution The classic bell curve whose properties were proved by Gauss. The Black-Scholes model assumes that the returns on shares follow a normal distribution.
Nostro account A bank's payment account held at another bank. From the Latin for 'our'.
Nostro reconciliation Checking that the expected cash movements resulting from trades are reflected in the actual movements of cash in the Nostro bank. *See*: Nostro account.
Notional principal The principal amount used to calculate payments on contracts such as interest rate swaps.
Novation The substitution of another party for one of the original parties to a contract. In derivatives, when the clearing house acts as central counterparty and becomes the buyer to the seller and seller to the buyer.
OAT French government bond.
Off-balance-sheet An item that does not appear on the assets or liabilities columns on a company's balance sheet. It can still give rise to contingent liabilities.
Offer price (ask price) The price at which a trader is prepared to sell an asset or derivative contract.
Off-market swap A non-par swap where the present values of the fixed and floating legs are not identical. Normally one party will make an initial payment to the other in compensation.
On-the-run bond The most recently issued and actively traded US Treasury for a given maturity.
Open interest The number of futures or options contracts for a given delivery month still open.
Open outcry market A physical market in which trades are conducted by dealers calling out prices.
Open position A long or a short position in assets or derivative contracts and which gives rise to market risk until it is closed out or hedged.
Operational risk According to the Basel Committee on Banking Supervision, the risk of loss resulting from failed or inadequate internal procedures, people and systems or from external events.
Option The right but not the obligation to buy or sell an asset at a fixed strike price by a set expiry date.
Order-driven market A market in which client buy and sell orders are directly matched.
Ordinary share UK expression. A stake in the equity of a company, carrying an entitlement to participate in the growth of the business and (normally) voting rights. The term 'common stock' is used in the US.
Out-of-the-money option For a call, when the strike is above the price of the underlying. For a put, when the strike is below the price of the underlying.
Outright forward FX A commitment to exchange two currencies at a fixed rate for a value date later than spot.
Overnight index swap (OIS) A fixed/floating interest rate swap in which the floating leg is linked to a published index of an overnight reference rate. At maturity one party pays to

the other the difference between the fixed rate and the geometrical average of the overnight rates over the life of the swap, applied to the notional principal.

Over-the-counter (OTC) transaction A deal agreed directly between two parties rather than through an exchange.

Par The face or nominal value of a bond or bill, normally paid out at maturity.

Par bond A bond that is trading at par.

Par swap An interest rate swap where the present values of the fixed and the floating legs are equal.

Parity Measures the equity value of a convertible bond. It is the bond's conversion ratio (the number of shares it converts into) times the cash or spot price of each share.

Pass-through security A security backed by underlying loans such as mortgages. The cash flows from the loans are passed through on a pro-rata basis to make the principal and interest payments to the bondholders. *See*: Collateralized debt obligation.

Physical delivery The process of delivering the underlying commodity or financial asset specified in a derivative contract.

Plain vanilla The most standard form of a financial instrument.

Political risk The risk of losses arising from exceptional activities by governments, e. g. halting foreign exchange trading in the national currency, or imposing special taxes.

Portfolio insurance A hedging technique much maligned (probably unjustly) in the aftermath of the 1987 stock market crash. It involves dynamically adjusting a hedge as the market moves by, e. g., trading index futures.

Portfolio management Managing money by holding a diversified portfolio of assets.

Position The net total of long and short contracts. A trader who buys 50 September S&P 500 futures and sells 70 of the same contracts is net short 20 contracts. The trader is exposed to market risk unless the position is closed out or hedged.

Premium In the options market, premium is the price of an option – the sum the buyer pays to the writer.

Present value The discounted value of a future cash flow or cash flows.

Protective put Buying a put option to protect against losses on an asset.

Proxy hedge A hedge that involves using a related financial instrument that is to some extent correlated with changes in the value of the underlying asset to be hedged.

Pull-to-par The movement in a bond price towards its par value as it approaches maturity.

Put–call parity A fixed relationship between the values of European calls and puts. It shows how long or short forwards can be assembled from a combination of calls and puts on the same underlying.

Put feature A feature of some bonds that allows the investor to sell them back to the issuer before maturity at a fixed price.

Put option The right but not the obligation to sell the underlying at a fixed strike price.

Putable swap A swap in which one of the parties can terminate the deal early.

Quanto option The payoff depends on an underlying denominated in one currency but is paid in another currency.

Quote-driven market One where market makers quote bid and offer prices.

Rainbow option The payoff depends on more than one underlying, e. g. the best performing of two equity indices.

Ratings agency Agencies, such as Moody's and Standard & Poor's and Fitch, which rate the default risk on corporate and sovereign debt.

Real interest rate or return An interest rate or rate of return (yield) on an investment excluding inflation. *See*: Nominal interest rate or return.

Recovery rate The amount that can be recovered on a loan or bond that defaults. In the CDS market the standard assumption is a 40% recovery rate, i.e. 40 cents in the dollar.

Redemption date The date when the face or redemption value of a security is repaid to the investors.

Reference entity The corporation or other organization on which protection is bought and sold in a credit default swap.

Reference obligation In a credit default swap**,** a security used to determine which assets of the reference entity can be delivered against the contract in the event of default. It is normally at the senior unsecured level.

Reset or refix date The date when the floating rate on a swap is reset for the next payment period.

Reverse FRN A special kind of floating rate note. The coupon rate moves inversely with current market interest rates. They can be extremely volatile.

Rho The change in the value of an option for a given change in interest rates.

Rights issue An issue of new shares by a company in which existing shareholders are given the right to buy the shares.

Risk-free rate The return on Treasury securities.

Risk management Monitoring, evaluating and hedging against potential losses caused by changes in asset prices, interest rates, currency exchange rates, etc.

Rollover In exchange-traded derivatives, rolling a position from one expiry or delivery month to a later month.

S&P 500® Standard & Poor's 500. An index based on the prices of 500 leading US companies, weighted by market capitalization.

Scalper Someone who buys and sells derivative contracts, usually on the same day, attempting to profit from the difference between the bid and the ask or offer price.

Securitization The process of creating asset-backed securities. Bonds are sold to investors which are backed by the cash flows from underlying assets, e.g. mortgage or credit-card loans.

Security Generic name for a negotiable (tradable) instrument such as a share, bond or bill.

Senior tranche Normally the safest class of securities in a securitization deal, which only suffers losses if the level of default in the underlying portfolio is substantial. Sometimes a 'super senior' tranche is created which ranks above the senior tranche.

Series Option contracts on the same underlying with the same strike and expiry.

Settlement date In the cash market, the date when a security is transferred and payment is made.

Settlement of difference With some derivative contracts there is no physical delivery. The difference between the contract price and the price of the underlying is settled in cash.

Settlement price The price used by a clearing house to mark-to-market a derivative contract. Usually an average of the last trades at the end of the trading day. At expiry a final settlement price is calculated.

Short position, short In derivatives, when more contracts have been sold than purchased.

Shout option The owner has the right to 'shout' at one time during the life of the contract and lock in a minimum payout.

Sigma Greek letter used to designate standard deviation. In derivatives used to denote volatility which is measured as the standard deviation of the returns on an asset.

SPAN® Standard Portfolio Analysis of Risk. A system developed on the CME to calculate margins on portfolios of derivative contracts.

Special purpose vehicle (SPV) A tax-exempt company or trust specially set up to implement a securitization. The SPV issues bonds and buys the title to the ownership of the cash flows which will repay the bonds. It manages the payments to the bondholders.

Spot foreign exchange rate The rate for exchanging two currencies in (normally) two business days.

Spot interest rate or yield Zero-coupon interest rate or yield.

Spot price The price of a security for spot delivery. Also known as the cash or current price.

Spread The difference between two prices or rates.

Spread trade A trade involving a combination of options.

Stamp duty A government tax on share dealings.

Stock index An index that tracks the changing price of a typical portfolio of shares. In the US key indices include the Dow Jones Industrial Average and the S&P 500. The most commonly quoted index in the UK is the FT-SE 100.

Stock index futures A futures contract based on an index such as the S&P 500 or the FT-SE 100. These are 'settlement of differences' contracts – there is no physical delivery of shares. On the main S&P 500 futures contract on CME each index point is worth $250.

Stock lending Holders of shares can make extra money by lending the shares to a borrower for a fee. The lender demands collateral to ensure that the shares are returned.

Stock option An option to buy or to sell a share (common stock in the US) at a fixed price.

Stock split When a company thinks its share price is too high it can issue a number of new shares to replace each existing share. Also known as a bonus or capitalization issue in the UK. A stock split differs from a rights issue or other secondary issue in that the company is not raising new capital.

Stop-loss order An order to a broker to close out a position and limit the losses whenever a given price level is reached.

Stop-profit order An order to a broker to close out a position and take the profits to date whenever a given price level is reached.

Straddle A combination option strategy which involves selling a call and a put (short straddle) or buying a call and a put (long straddle) on the same underlying with the same strike and the same time to expiration.

Straight ('plain vanilla') bond Pays fixed coupons on fixed dates and has a fixed maturity date.

Strangle Like a straddle except the options used in the strategy have different strikes.

Strike price Another term for the exercise price of an option.

Stripping and strips Also known as coupon stripping. Separating the principal and the interest payments on a coupon bond and selling off the parts as zero-coupon bonds.

Structured note A security usually assembled using derivatives that has nonstandard features, e. g. payments are linked to a commodity price or an equity index, or the difference between interest rates in two currencies, or the change in the creditworthiness of an entity or set of entities.

Swap A contract between two parties agreeing to make payments to each other on specified future dates over an agreed time period, where the amount that each has to pay is calculated on a different basis.

Swap curve A yield curve based on the fixed rates on standard par interest rate swaps.

Swap rate The fixed rate on an interest rate swap.

Swaption An option to enter into an interest rate swap. A payer swaption is an option to pay fixed and receive floating. A receiver swaption is an option to receive fixed and pay floating. May also be used to mean an option to enter into a credit default swap deal.
Synthetic securitization A securitization deal in which the underlying assets consist in a portfolio of credit default swaps rather than actual loans or bonds.
Systematic risk Undiversifiable or market risk. The risk that remains in a highly diversified portfolio of assets.
Systemic risk The risk that an event such as a bank failure might have a domino effect on the rest of the financial system.
Tenor Time to maturity.
Term structure of interest rates Spot or zero-coupon rates for a range of maturities.
Theta The change in the value of an option as time elapses, all other factors remaining constant.
Tick size In theory, the smallest movement allowed in a price quotation, though some exchanges may allow half- or even quarter-tick price changes on some contracts.
Tick value The value of a one-tick movement in the quoted price on the whole contract size.
Time spread *See*: Calendar spread.
Time value The difference between an option's total value and its intrinsic value.
Time value of money The basis of discounted cash flow valuation. If interest rates are positive then $1 today is worth more than $1 in the future because it can be invested and earn interest.
Trade failure (fail) When something goes wrong in the settlement of a trade.
Trader An individual or an employee of a financial institution who buys and sells securities or derivative contracts.
Tranche (Slice) In a securitization different tranches of bonds are sold with different risk/return characteristics to appeal to specific investor groups.
Transition matrix A table that helps to predict the probability that the credit rating of a company will change to different levels over a specified period of time.
Treasury bill (T-Bill) A short-term negotiable debt security issued and fully backed by a government.
Treasury bond A longer-term debt security issued and fully backed by a government.
Triple witching-hour US expression for the time when stock and index options and index futures all expire.
Two-way quotation A dealer's bid (buy) and ask (offer or sell) price.
Ultra vires Beyond the legal power. Used when an organization enters into a transaction which it is not legally entitled to conduct.
Underlying The asset that underlies a derivative product. The value of the derivative is based on the value of the underlying.
Up-and-in option Comes into existence if the underlying rises to reach a barrier or threshold level.
Up-and-out option Goes out of existence if the underlying rises to reach a barrier or threshold level.
Upside potential Potential for profits.
Value-at-risk (VaR) A statistical estimate of the maximum loss that can be made on a portfolio of assets to a certain confidence level over a given time period.
Variation margin Additional margin paid or received when a derivative contract is marked-to-market and there is a margin call from the clearing house.

Vega The change in the value of an option for a given change in volatility.

Vix Index The CBOE® Volatility Index (VIX) measures the expected volatility on the S&P 500 index over the near-term (30 days) using the prices of a range of S&P index option contracts. The VIX is sometimes called the 'investor fear gauge' because it tends to rise during periods of increased anxiety in the financial markets.

Volatility A key component in option pricing. A measure of the variability of the returns on the underlying. It is based on historic evidence or future projections.

Volatility smile A graph showing the implied volatilities of options on the same underlying for a range of strikes. Used to pinpoint the correct volatility to price or revalue options. In practice the graph may be a skew rather than a smile.

Volatility surface A three-dimensional graph showing the implied volatilities of options on the same underlying for a range of different strike prices and expiration dates.

Warrant A longer-dated option in the form of a security which can be freely traded, often on a stock exchange. Issuer warrants are issued by a company on its own shares. Covered warrants are sold by banks and securities houses and are based on another company's shares or on baskets of shares; they may be settled in cash.

Weather derivatives Financial products whose payoffs are based on measurable weather factors such as temperature or rainfall recorded at specific reference locations.

Withholding tax When a proportion of a coupon or dividend payment is withheld from the investor by the issuer and paid over to the government in tax.

Writer The party that shorts an option. The writer is paid a premium by the buyer of the option.

Yield The return on an investment, taking into account the amount invested and the expected future cash flows.

Yield curve A graph showing the yields on a given class of bonds (e.g. US Treasuries) against time to maturity.

Yield-to-maturity The total return earned on a bond if it is bought at the current market price and held until maturity with any coupons reinvested at a constant rate.

Zero-cost collar A collar strategy with zero net premium to pay. The premiums on the call and put cancel out.

Zero-coupon bond A bond that does not pay a coupon and trades at a discount to its par or face value. At maturity the holder of the bond is repaid the face value.

Zero-coupon rate (spot rate) The rate of interest that applies from now to a specific date in the future. It is used to price products such as interest rate swaps because no reinvestment assumptions need be made.

Zero-coupon swap The fixed rate is compounded over the life of the swap and paid at maturity rather than in instalments.

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Index compiled by Terry Halliday