

Fundamentals of Commodities and Derivatives

After the publication of the first edition of this text, many of the author's friends not involved with financial markets often asked, 'what are commodities'? Like many innocent questions, they are often very difficult to answer. In one sense, they are largely unprocessed or semi-processed goods, which are either consumed or can be processed and then resold. However, this definition will not always universally apply; for example, freight and carbon emission markets do not easily fall within this category.

In general terms, commodities can be classified under different headings:

Energy markets

- Crude oil and refined products (e.g. WTI/Brent, gasoline)
- Power and natural gas
- Natural gas liquids (e.g. propane and butane)
- Coal

Industrial metals

- Copper, aluminium

Precious metals

- Gold, silver

Agricultural products

- Grains
- Softs (e.g. coffee)
- Livestock

'Specialty' markets

- Forest products (e.g. pulp and recovered paper)
- Carbon emissions
- Weather
- Freight

1.1 MARKET OVERVIEW

Figure 1.1 is a ‘big picture’ overview of commodity markets.

In this diagram there are two main segments, the physical and the financial markets. The diagram was designed without a specific product in mind, but if the reader prefers some context, it may be helpful to think of a popular commodity such as crude oil. Within the physical side of the market there will be three main participants: producers, refiners, and consumers. In addition, trading houses will perform a variety of tasks, which are detailed in a subsequent section. The financial side of the market will incorporate those entities offering financing and risk management services as well as investors seeking to earn a return from the asset class. One aspect that is central to commodities is price discovery, and so the role of futures exchanges is key.

To get a sense of the generic market flows associated outlined in Figure 1.1, consider the following issues faced by market participants:

- *Commodities are not homogeneous* – it is not particularly helpful to speak in general terms about commodities. For example, the phrase ‘crude oil’ is meaningless as the chemical properties of crude extracted in one location will vary from those in a different location. Trafigura (2016) argues that over 150 types of crude oil are traded worldwide.

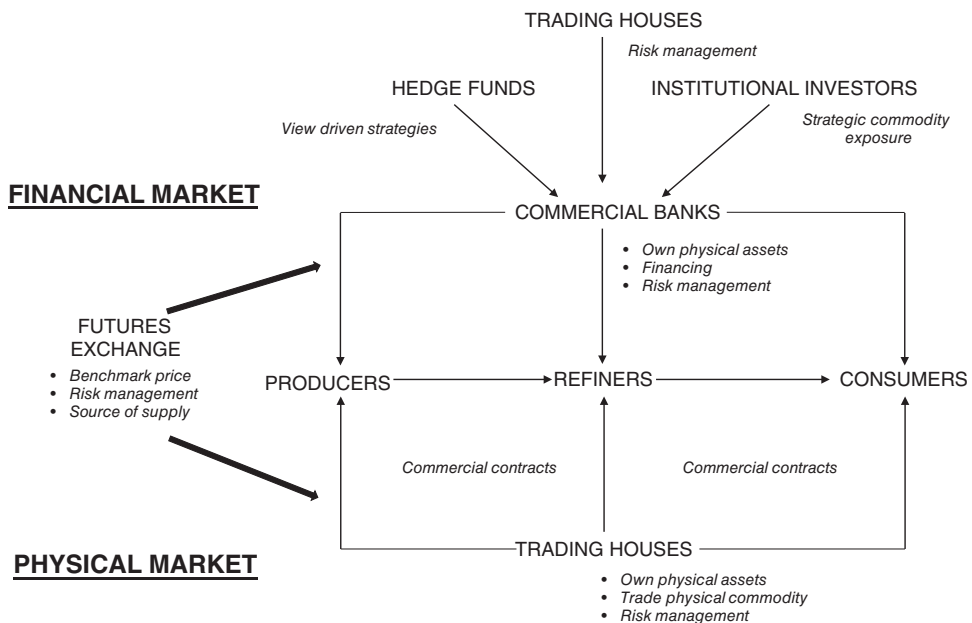


FIGURE 1.1 Commodity market overview.

- *Commodities need to be transformed into consumer goods* – for example, oil needs to be refined to produce gasoline.
- *Benchmarks help participants agree on a price for non-homogeneous products* – so with respect to crude oil, a particular grade of oil could be priced relative to an agreed benchmark such as a futures contract that references Brent Blend.
- *Production and consumption may not take place in the same geographical location* – this means that there is a need for transportation. The mode of this transportation can vary for a single commodity. For example, in the USA, crude oil is typically moved by pipeline or train. In other areas such as Europe, sea-borne transport may be more common.
- *Consumption and production may not occur simultaneously* – a consumer may not need to take immediate delivery of a commodity, therefore storage and inventories are key factors. When there is a geographic element to the issue, it takes time for a commodity to be transported.

1.2 MARKET PARTICIPANTS

Market participants are able to manage the respective price risks using derivatives. Although risk management will be considered in greater detail in Chapter 3, it is worth considering some related motivations.

Participants can:

- Avoid risk,
- Retain risk,
- Transfer risk,
- Reduce risk,
- Increase risk.

One of the key roles of derivatives is that they allow different market participants with different risk profiles and objectives to obtain a desired risk exposure. With respect to commodity derivatives the main participants will be physical market participants, price reporting agencies (PRAs), investment banks, commodity trading houses, hedge funds, or ‘real’ money accounts.

1.2.1 Physical market participants

Individual product supply chains will be considered in the respective chapter. In general terms, the commodity will need to be produced, refined, and then transformed into a product that can be consumed by the end user. Admittedly this general description does not capture all the different types of commodity supply chains, but the key point is that the participant will typically have some form of price risk at most points along the supply chain

In simple terms, producers will be exposed to falling prices, consumers will be exposed to rising prices, and refiners, processors, and utilities will be exposed to

margins (e.g. the income generated from selling gasoline less the cost of buying crude oil). These participants are also faced with a variety of other risks which include:

- Credit, i.e. the unwillingness or inability of a customer to pay their debts.
- Logistical risks surrounding the movement of the commodity.
- Sourcing the right quality of commodity.
- Being able to finance day-to-day operations.

1.2.2 Price reporting agencies (PRAs)

One of the problems faced by various commodity markets over the years is one of price discovery. How does a market participant know if they are achieving fair market value? Consider the following quote from a market participant in 2011 with respect to the metal Rhodium, which was about to be used in the creation of an exchange traded fund aimed at the retail market:

‘With no futures benchmark . . . all the spot price transparency of molasses . . . and a risk reward with which only a supremely knowledgeable professional or those wet behind the ears would be comfortable . . . guess the target audience?’
(*Financial Times*, 2011)

Since commodities are heterogeneous products, establishing a fair price has always been a challenge for market participants and the main conventions used either involve exchange traded prices (where available) or index values determined by PRAs. IOSCO (2012) defines a PRA as:

‘Publishers and information providers who report prices transacted in physical and some derivative markets and give informed assessment of price levels at distinct points in time’.

They defined a crude oil assessment as:

‘The process of applying a methodology and/or judgement to market data and other information to reach a conclusion about the price of oil’.

In response to IOSCO, one of the PRAs, Platts (2012) described their activities in relation to crude oil as follows:

‘Platts publishes assessments of spot prices for crude oil and refined products in various geographic regions based on a range of factual inputs including information on individual transactions supplied by market participants . . . Given the heterogeneous nature of the underlying transactions (in terms of trading parties, product quality, location, timing, delivery terms and other factors), the analysis conducted by Platts in determining its published price assessments is essentially qualitative, albeit based on a range of quantitative and factual inputs’.

Price indexes can be used as the basis for settling commercial supply contracts (as could futures prices) or, in some cases used to determine the value of cash-settled futures transactions.

1.2.3 Investment banks

The services offered by investment banks will vary according to the business model that they adopt. Some banks may consider themselves to be a ‘full service’ entity, offering the ability to deal not just in derivatives, but to become counterparty to a physical trade. Other banks may offer more limited services, such as having a derivative service without the capability to execute physical transactions.

A ‘full service’ bank will be able to offer several solutions to physical participants with some hypothetical examples shown in Table 1.1.

1.2.4 Commodity trading houses

The commodity trading house Glencore Xstrata describe themselves as follows (Glencore, 2011): ‘(the company) is a leading integrated producer and marketer of commodities, with worldwide activities in the marketing of metals and minerals, energy products and agricultural products and the production, refinement, processing, storage and transport of these products. Glencore operates globally, marketing and distributing physical commodities sourced from third party producers and own production to industrial consumers’. Traditionally, commodity trading houses would have simply bought commodities from producers and then sold them to consumers. However, the definition presented by Glencore Xstrata suggests that over time these entities have evolved to own and operate significant parts of various commodity supply chains. So, the notion of one company being fully integrated along a supply chain is no longer the norm. Indeed, many of the investment banking services highlighted in Table 1.1 could conceivably be offered by trading houses.

A report by the *Financial Times* (2013) highlighted the extent of trading house involvement in the market:

TABLE 1.1 Examples of services that could be provided by banks to facilitate commodity production and consumption.

Sector	Problem	Solution
Crude oil and refined products	Inventory is working capital intensive	Bank agrees to own inventory
Natural gas	Cold weather creates increased demand, but there are delivery constraints with existing pipeline infrastructure	Banks buy pipelines or own storage facilities
Base metals	Consumers seek favourable payment terms	Banks provide finance along the logistics chain or act as an intermediary between consumers and producers

- Those trading oil handled more than 15m barrels of oil a day.
- The main agricultural trading houses handled about half of the world's grain and soybean trade flows.
- Two trading houses controlled about 60% of the zinc market.
- Relatively unknown companies can dominate smaller niche markets such as coffee.

Their growth was attributed to four main factors:

- The economic boom after 2000 in several emerging economies.
- A strategic decision to acquire physical assets.
- Their ability to exploit price arbitrage opportunities because of their increasing presence along the supply chain.
- Consolidation in the period prior to 2000 which reduced competition.

1.2.5 Hedge funds

There is no single definition of a hedge fund given the wide range of structures and strategies used in this section of the market. However, they can be defined in terms of their characteristics:

- Investment 'vehicles' that pool the proceeds of their investor base.
- Access tends only to be available to a limited group of investors.
- Proceeds are actively managed.
- They aim to generate a return irrespective of underlying market conditions.

They are often associated with aggressive 'view driven' strategies and Chapter 3 includes a case study of the commodity hedge fund Amaranth that failed when its strategy in the US natural gas markets resulted in substantial losses.

1.2.6 'Real money' accounts

A real money participant is usually classified as an entity that is not able to borrow money to boost their available investment proceeds. Typically, this could include entities such as pension funds and insurance companies. Their participation in the commodity market is primarily for investment purposes. Also within this category it may be possible to include private and commercial banks that are offering commodity investment products to their retail customers.

1.3 TRADED VERSUS NON-TRADED COMMODITIES

One of the subtle characteristics of commodity markets is the difference between traded and non-traded commodities. What is the difference?

An interesting case study that illustrates the key differences is the market for iron ore. Iron ore is used in the production of steel and, combined with steel, represents the world's second largest commodity bloc by value (ICE, 2009). Macquarie Bank (2013)

points out that prior to 2003 the concept of a spot market for the metal did not exist in any meaningful sense. At this time, the traditional buyers were Japanese and Korean steel producers who purchased their metal using annual, fixed price, bilateral contracts with suppliers based mainly in Brazil and Australia. The annual benchmark price typically ran from 1 April–31 March in the following year. Emerging new consumers such as China struggled to purchase the required amount of metal under this market mechanism as the traditional sources of supply could not keep pace with the extra demand. This coincided with a new source of supply from India that was able to react quickly. This led to more ‘one-off’ transactions that resulted in the emergence of a spot market. At the same time commodities that were inputs to the steel making process, which already had developed spot markets, became more volatile. This increased the pressure on iron ore to respond accordingly.

However, the phrase ‘spot’ within the context of commodities can sometimes be applied ambiguously. For example, in certain markets (e.g. gold), spot transactions will have a similar maturity to those seen in traditional financial markets (e.g. trade date plus two good business days). In other instances (e.g. crude oil), delivery is unlikely to occur in such a short time frame. ‘Spot pricing’ could also indicate that the contract is for short-term delivery with prices possibly referencing exchange traded futures prices.

The increase in spot transactions meant that price-reporting companies now disseminated information on physical transactions on a more regular basis. One of the characteristics noted earlier is that commodity markets lack homogeneity and therefore pricing from a single benchmark has become the accepted practice. For iron ore a popular benchmark that has emerged is iron ore with a grade of 62%¹.

The development of pricing benchmarks is an important step in the development of a commodity’s tradable status:

- They represent a standard reference point, which is based on actual market activity and is understood by market participants.
- Participants can enter commercial contracts or reference financial contracts to a price that is transparent, representative of the most liquid market, and is determined by a publicly available process.
- The benchmark price is *the* price of the commodity if it is used by many and varied participants.
- Once a benchmark price emerges, market participants can trade different grades of the commodity as a differential. So, iron ore with a grade of 58% would trade below the benchmark price, while a 65% grade would trade above the price. These differentials may also reflect the products’ country of origin and its availability.
- The emergence of a benchmark may result in the development of financial markets (e.g. derivatives) that can facilitate the hedging of underlying exposures.

¹Ore is essentially the rock that is extracted from through the mining process, which is then refined to extract the desired elements, such as iron. The ores may be classified by the amount of desired element that they contain. For example, iron ore ‘fines’ (heavy grains) can vary in grade from 30% to the mid 60%. (ICE, 2009)

The increased reporting of iron ore prices meant that the spot price provided a reference point for those entities still using the annual benchmark negotiations. Indeed, because of the financial crisis the spot price of the metal fell below the annual benchmark. This resulted in several consumers defaulting on their fixed price agreements in order to take advantage of the lower spot price. Once price assessments started to appear daily, which reported a standard grade of iron ore, financial products began to emerge. Exchange traded iron ore swaps were the first derivative that referenced this product. Thereafter, a forward curve for iron ore started to form, which was later boosted by the emergence of over-the-counter swaps and iron ore futures.

1.4 FORWARD CONTRACTS

A forward contract will fix the price today for delivery of an asset in the future. Gold sold for spot value will involve the exchange of cash for the metal in two days' time. However, if the transaction required the delivery in, say, one month's time, it would be classified as a forward transaction. Forward contracts are negotiated bilaterally between the buyer and seller and are often characterized as being 'over-the-counter' (OTC).

The forward transaction represents a contractual commitment and so, if gold is bought forward at USD 1,430.00 an ounce, but the price of gold in the spot market is only USD 1,420.00 at the point of delivery, one cannot walk away from the forward contract and try to buy it in the underlying market. However, it is possible for both parties to mutually agree to terminate the contract early. This could be achieved by agreeing upon a 'break' amount, which would reflect the current economic value of the contract. Typically, this is done using a process that is referred to generically as 'marking to market'. An easier way to understand the issue is to use the concept of an exit price. This is typically taken to be the amount for which an asset could be sold, or a liability settled in an 'arm's length' transaction.

A variation on the standard contract is a floating forward. In this type of transaction, a market participant commits to buy or sell the underlying at a future date, but the applicable price is only set at the point of delivery. The final price that is agreed upon may be based on some pre-agreed formula. For example, the price could be the average of daily spot prices in the month prior to settlement.

1.5 FUTURES

A futures contract is traded on an organised exchange, with the CME Group being one example. Economically, a future achieves the same result as a forward by offering price certainty for a period in the future. However, the key difference between the contracts is in how they are traded. The contracts are uniform in their trading size, which is set by the exchange. For example, the main features of the contract specification for the gold future appear in Table 1.2.

TABLE 1.2 Gold futures contract specification.

Trading unit	100 troy ounces
Price quotation	US dollars and cents per troy ounce
Trading months	Trading is conducted for delivery during the current calendar month; the next two calendar months; any February, April, August, and October falling within a 23-month period; and any June and December falling within a 72-month period beginning with the current month.
Minimum price fluctuation	USD 0.10 (10c) per troy ounce (USD 10.00 per contract)
Last trading day	Trading terminates at the close of business on the third to last business day of the maturing delivery month.
Settlement method	Deliverable
Delivery period	The first delivery day is the first business day of the delivery month. The last delivery day is the last business day of the delivery month.
Margin requirements	Margins are required for open futures positions.

Source: CME Group

Traditionally, there are some fundamental differences between commodity and financial products traded on an exchange basis. Historically, one of the key differences is that futures require collateral to be deposited when a trade is executed (known as initial margin). As a rule of thumb, the initial margin will be about 5% of the market value of the contract. Although different exchanges will work in different ways, the remittance of profits and losses may take place on an ongoing basis (variation margin) rather than at the maturity of the contract. However, financial markets have evolved such that OTC forward contracts will now have very similar margining requirements to futures contracts.

Another difference between forwards and futures relates to the grade and quality specification. If one is delivering a currency, the underlying asset is homogenous – a dollar is always a dollar. However, because metals vary in shape, grade, and quality, it is important to ensure an element of standardisation so the buyer knows what they are receiving. Some of the criteria that CME Group apply include:

- The seller must deliver 100 troy ounces (+/-5%) of refined gold.
- The gold must be of a fineness of no less than 0.995.
- It must be cast either in one bar or three one-kilogram bars.
- The gold must bear a serial number and identifying stamp of a refiner approved and listed by the Exchange.

Anecdotal estimates suggest that the vast majority (ca. 95%) of futures contracts are terminated prior to their expiry date. This is perhaps a reflection that most participants will use the instruments for risk management purposes rather than as a source of supply.

1.6 SWAPS

In a swap transaction two parties agree to exchange cash flows, whose size are based on different price indices. Typically, this is represented as an agreed fixed rate against a variable or floating rate. Swaps are traded on an agreed notional amount, which is not exchanged but establishes the magnitude of the fixed and floating cash flows. Swap contracts are typically of longer-term maturity (i.e. greater than one year) but the exact terms of the contract will be open to negotiation. For example, in many base metal markets a swap transaction is often nothing more than a single period forward. This is because the forward transaction may be cash settled which would involve the payment of the agreed forward price against the spot price at expiry.

The exact form may vary between markets, with the following merely a sample of how they may be applied in a variety of different commodity markets.

- Gold – Pay fixed lease rate vs. receive variable lease rate
- Base metals – pay fixed aluminium price vs. receive average price of near dated aluminium future
- Oil – pay fixed West Texas Intermediate (WTI) price vs. receive average price of near dated WTI future

Swaps will usually be spot starting and so become effective two days after they are traded. However, it is also possible for the swap to become effective sometime in the future – a forward starting swap. The frequency with which the cash flows are settled is open to negotiation but they could vary in tenor between 1–12 months. Where the payments coincide, there is a net settlement between the two parties. One of the features of commodity swaps not shared by financial swaps is the use of an average rate for the floating leg. This is because many of the underlying exposures that commodity swaps are designed to hedge will be based on some form of average price.

The motivation for entering a swap will differ between counterparties. For a corporate entity one of their main concerns is risk transference. Take a company that purchases a particular commodity at the market price at regular periods in the future. To offset the risk that the underlying price may increase, they would receive a cash flow under the swap based on movements in the market price of the commodity and pay a fixed rate. If the counterparty to the transaction were an investment bank, the latter would now have the original exposure faced by the corporate. The investment bank would be receiving fixed and paying a variable rate, leaving them exposed to a rise in the price of the underlying commodity. In turn, the investment bank will attempt to mitigate this exposure by entering some form of offsetting transaction. The simplest form of this offsetting deal would be an equal and opposite swap transaction. To ensure that the bank makes some money from this second transaction, the amount they receive from the corporate should offset the amount paid to the offsetting swap counterparty.

Swaps are typically traded on a bid-offer spread basis. From a market maker's perspective (that is the institution giving the quote) the trades are quoted as follows:

Bid	Offer
Pay fixed	Receive fixed
Receive floating	Pay floating
Buy	Sell
Long	Short

Although the terms buy and sell are often used in swap quotes, the actual meanings are often confusing to anyone looking at the market for the first time. In the author's opinion, the most unambiguous way to trade these instruments is to state who is the payer and who is the receiver of the fixed rate. The convention in all swap markets is that the buyer is receiving a stream of variable cash flows for which the price is a single fixed rate. Selling a swap requires the delivery of a stream of floating cash flows for which the compensation is a single fixed rate.

1.7 OPTIONS

A forward contract offers price certainty to both counterparties. However, the buyer of a forward is locked into paying a fixed price for a particular commodity. This transaction will be valuable if the price of the commodity subsequently rises, but will be unprofitable in the event of a fall in price. An option contract offers the best of both worlds. It will offer the buyer of the contract protection if the price of the underlying moves against them, but allows them to walk away from the deal if the underlying price moves in their favour.

This leads to the definition of an option as the right, but not the obligation, to either buy or sell an underlying commodity sometime in the future at a price agreed upon today. An option that allows the holder to buy the underlying asset is referred to as a call. Having the right to sell something is referred to as a put. The price at which the two parties will trade if the option is exercised is referred to as either the strike price or the exercise price. The strike can be set at any level and is negotiated between the option buyer and seller.

Options may be either physically settled (that is, the commodity is delivered/received) or cash settled. The process of cash settlement removes the need to make or take delivery of the underlying asset, but retains the economics of a physically settled option. Cash settlement involves the seller paying the buyer the difference between the strike and the spot price at the point of exercise. The payoff for a cash-settled call option is:

$$\text{MAX} (\text{underlying price} - \text{strike price}, 0)$$

Where: MAX means ‘the maximum of’

The payoff for a cash-settled put option is:

$$\text{MAX}(\text{strike price} - \text{underlying price}, 0)$$

Options come in a variety of styles relating to when the holder can exercise their right. A European style option allows the holder to exercise the option only on the final maturity date. An American style option allows the holder to exercise the option at any time prior to final maturity. A Bermudan option allows the holder to exercise the option on a pre-agreed set of dates prior to maturity.

An option that is in-the-money (ITM) describes a situation where it would be more advantageous to trade at the strike rather than the underlying market price. Take for example an option to buy gold at USD 1,400 an ounce when the current spot price is say, USD 1,425. The option to buy at the strike is more attractive than the current market price. Where the option is out-of-the-money (OTM), the strike is less attractive than the market price. If the same option had a strike rate of USD 1,430, the higher strike makes the option less attractive than buying the underlying at a price of USD 1,420. Finally, an option where the strike is equal to the current market price is referred to as an at-the-money (ATM).

Since options confer rights to the holder, a premium is payable by the buyer. Typically, this is paid upfront, but certain option structures are constructed to be zero premium or may involve deferment of the premium to a later date. Premiums on options are quoted in the same units as the underlying asset. So, since physical gold is quoted in dollars per troy ounce, the premium will be quoted in the same manner.

Many of the derivatives strategies based on options that are discussed within the text are illustrated based on the value of the option at maturity. These are illustrated as follows:

In the upper left-hand of Figure 1.2, the purchase of a call option is illustrated. If at expiry the option market price is lower than the strike, the option is not exercised, and the buyer loses the premium paid. If the underlying price is higher than the strike price, the option is exercised and the buyer receives the underlying asset (or its cash equivalent), which is now worth more in the underlying market than the price paid (i.e. the strike price). This profit profile is shown to the right of the strike price. On the other side of the transaction there is the seller of a call option (top right quadrant of Figure 1.2). The profit and loss profile of the seller must be the mirror of that of the buyer. So, in the case of the call option, the seller will keep the premium if the underlying price is less than the strike price, but will face increasing losses as the underlying market price rises.

The purchase of a put option is illustrated in the bottom left quadrant of Figure 1.2. Since this type of option allows the buyer to sell the underlying asset at a given strike price, this option will only be exercised if the underlying price falls. If the underlying price rises, the buyer loses the premium paid. Again, the selling profile for the put is the mirror image of that faced by the buyer. That is, if the underlying price falls, the seller will be faced with increasing losses. However, if the market price rises, the seller will keep the premium.

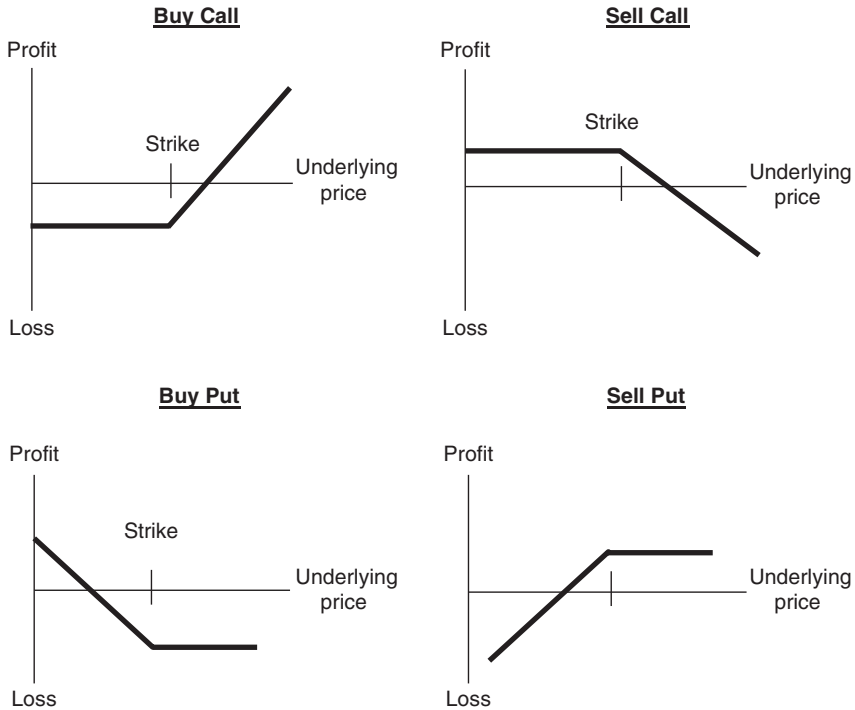


FIGURE 1.2 Profit and loss profiles for options at expiry.

Options arguably offer great flexibility to the end user. Depending on their motivation, it can be argued that option usage are categorised in four different ways. Firstly, they can be used to take a directional exposure to the underlying market. For example, if a user thought the underlying price of gold might increase, they could buy physical gold, a future, or a call option. Buying physical gold requires the outlay of proceeds, which may need to be borrowed. Buying a future reduces the initial outlay of the physical but will incur a loss if the future's price falls. Buying a call option involves some outlay in the form of premium but allows for full price participation above the strike and limited downsides if the price falls. The second usage for options is an asset class in its own right. Options possess a unique feature in implied volatility, and this can be isolated and traded. The focus of this type of strategy is how the option behaves prior to its maturity. The third motivation, which is particularly relevant to the corporate world, is as a hedging vehicle that allows a different profile than that of the forward. With a little imagination it is possible to structure solutions that will offer differing degrees of protection against the ability to profit from a favourable movement in the underlying price. The final motivation is options as a source of outperformance. For example, if an end user owns the underlying asset (e.g. central bank holdings of gold) they can use options to exceed some performance benchmark such as money market deposit rates. From a hedger's perspective, options could be used to outperform an ordinary forward rate.

1.8 EXOTIC OPTIONS

Exotic options are a separate class of options where the profit and losses upon exercise do not correspond to the plain vanilla American and European styles. Although there is a proliferation of different types of exotic options, it is worth introducing some of the key building blocks, which feature prominently in derivative structures.

1.8.1 Binary options

A binary option (sometimes referred to as a digital) is very similar to a simple bet. The buyer pays a premium and agrees to receive a fixed return. Very often the strike rate on the digital is referred to (somewhat confusingly) as a barrier. With a European style call option, the holder will deliver the strike price to the seller and receive a fixed amount of gold. However, the value of the gold will depend on where the value of gold is trading in the spot market upon exercise. With a binary option the buyer will receive a fixed sum of money if the option is exercised, irrespective of the final spot level.

An example of a long digital call and a long digital put is shown in Figure 1.3.

1.8.2 Barrier options

The purchaser of a barrier option will either:

1. Start with a conventional 'plain vanilla' option that could subsequently be cancelled prior to maturity (known as a *knock out*), or,
2. Start with nothing and be granted a conventional option prior to the maturity of the transaction (known as a *knock in*).

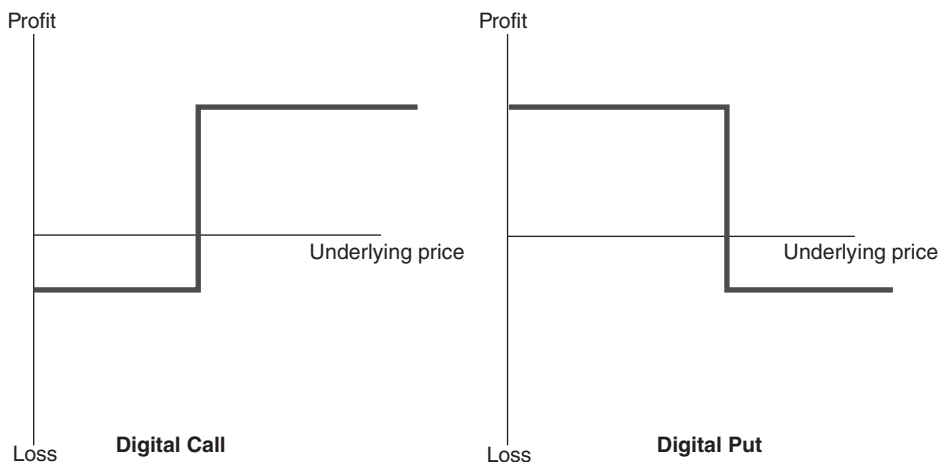


FIGURE 1.3 Digital calls and puts.

The cancellation or granting of the option will be conditional upon the spot level in the underlying market reaching a certain level, referred to either as a barrier or trigger level.

The position of the barrier could either be placed in the out-of-the money region or in the in-the-money region. This will be above or below the current spot price, as we will show below. The former are referred to as standard barriers with the latter known as reverse barriers. This could result in what may initially seem like a bewildering array of possibilities. Figure 1.4 summarises the concepts.

To illustrate the concept further let us return to the option example illustrated earlier and concentrate on analysing a call option. We will assume the option is out-of-the-money and the current market conditions exist:

Spot	USD 1,425
Strike	USD 1,430
Maturity	Three months

The purchaser of a standard knock in barrier option would be granted a European style option if spot hit a certain trigger. Since it is a standard barrier option, the trigger must be placed in the out-of-the-money region so it would be set at say, USD 1,420. Consequently, spot must reach USD 1,420 or below before the option is activated (knocked in), hence the name a down and in. If the purchaser started with a standard barrier call option with the trigger at USD 1,420, it would be a down and out. That is, if spot were to fall to USD 1,420 or lower the option contract would be cancelled. A reverse knock in call option would have the barrier placed in the money at, say, USD 1,435. A purchaser of such an option would have a contract that would grant a call option with a strike of USD 1,430 if spot hits USD 1,435. The final example would be a reverse knock out call option, with the trigger again set at USD 1,435. Here the purchaser starts the transaction with a regular call option, which would be cancelled if spot reached USD 1,435 – an up and out contract.

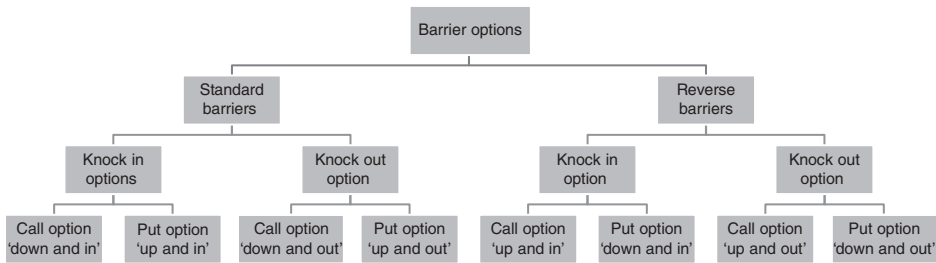


FIGURE 1.4 Taxonomy of barrier options.

1.8.3 Spread options

A spread option pays off based on the difference between the price of two underlying assets, relative to a pre-agreed strike. A call option will pay off if the spread is greater than the strike, while a put option will pay off if the spread is lower than the strike.

$$\text{Call payoff} = \text{MAX} (\text{Price of asset 1} - \text{price of asset 2} - \text{strike}, 0)$$

$$\text{Put payoff} = \text{MAX} (\text{Strike} - \text{price of asset 1} + \text{price of asset 2}, 0)$$

Spread options are relatively more popular in commodities than in traditional financial assets. For example, a participant may wish to hedge or take exposure between:

- The cost of an input and the revenue earned from an output (e.g. cost of crude oil and revenue from gasoline).
- The prices between a commodity traded at two different locations.
- The price of a single commodity future for two different delivery dates.

These examples will be discussed in detail in their respective chapters. From a valuation perspective, these options require an additional valuation input and that is the correlation that exists between the two asset prices. To illustrate this, consider a spread option structured as a call, which will pay off if the spread between two asset prices increases beyond a pre-agreed strike. If the two asset prices are negatively correlated, an increase in asset price 1 will be associated with a decrease in asset price 2. This relationship increases the probability that the option will end up more deeply in the money and as such the seller will charge a higher price.

1.8.4 Average rate options

Anecdotally, average rate options ('avros') are the most common type of commodity option. Regular or 'vanilla' option payoffs will reference a single underlying asset price at maturity, with the payoff being made relative to the strike. However, an average rate option will pay out based on an average of prices covering a pre-agreed period prior to maturity.

The expiry payoffs of average rate options are:

$$\text{Call option} = \text{MAX} (\text{average underlying price} - \text{strike price}, 0)$$

$$\text{Put option} = \text{MAX} (\text{strike price} - \text{average underlying price}, 0)$$

One of the reasons for the popularity of such contracts in commodities is that it reflects the way in which physical supply contracts are structured. A refiner who agrees to buy crude oil from a producer will avoid paying a potentially high price if the terms of the deal reference market prices on a single date. Although averaging prices will dampen the effect of volatile price movements it also means that the refiner will not be able to benefit if the price of the commodity suddenly falls. A common feature of

commodity derivatives is that the payoff on the instrument should match that of the commercial contract to avoid a cash flow mismatch.

One of the characteristics of an average rate option is that they will show a premium reduction over the equivalent European option; it is not really a cheap alternative to a vanilla option. As an example, the cost of a six-month call option on a crude oil future with an at-the-money strike price of USD 50.00 and an implied volatility of 30%. The cost of a vanilla option on this asset is USD 4.20/barrel, but if the terms of the contract are altered such that the final settlement price is an average of the futures prices over the last three months of the transaction, the cost of the option falls to USD 3.96. This is because the implied volatility of the average rate option references an average price series which will be lower than a non-averaged equivalent. Another way of thinking about the problem is that since the premium of an option is a function of payoff received by the buyer, a payoff based on an average price series will always be lower than a non-averaged equivalent.