5 Derivative markets: options

5.1 Learning outcomes

After studying this text the learner should / should be able to:

1. Define an option.
2. Elucidate the characteristics of an option.
3. Describe the different types of, and concepts relating to options.
4. Explain the payoff profiles of the various option types.
5. Comprehend intrinsic value and time value.
6. Elucidate the motivation for undertaking (buying or writing) option contracts.
7. Comprehend option strategies.
8. Understand delta hedging.

5.2 Introduction

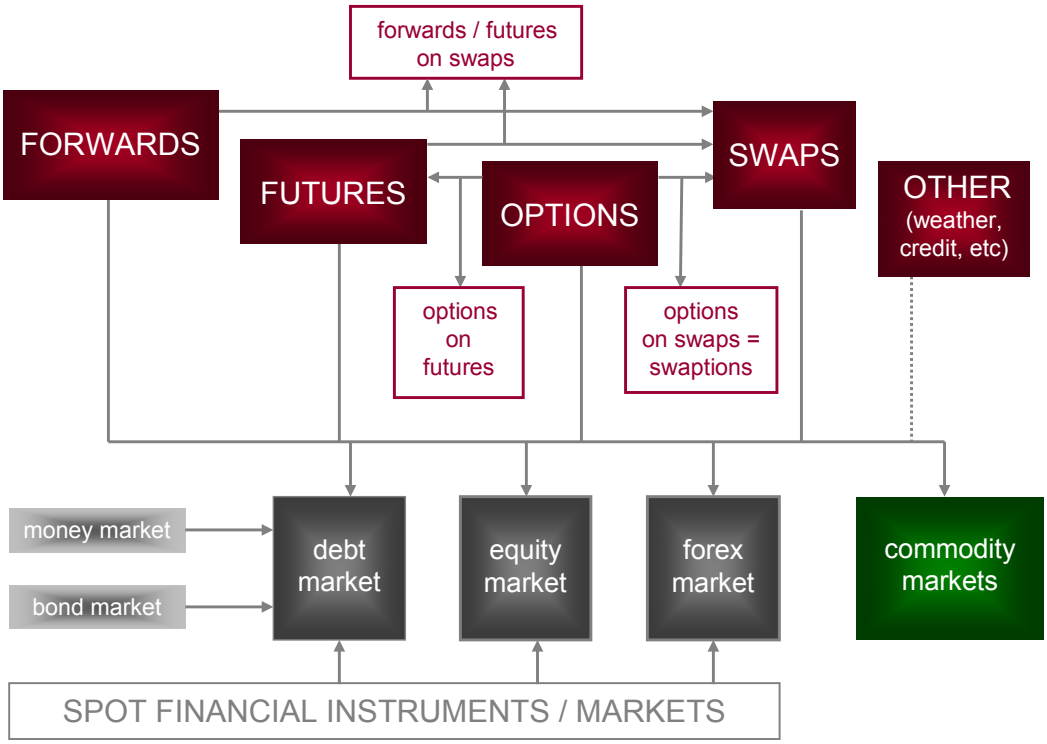

Figure 1: derivatives and relationship with spot markets

A depiction of the derivatives markets and their relationship to the spot markets is shown in Figure 1. The figure shows that there exist *options on specific instruments* (called "physicals") in the various financial markets and the commodities market, and *options on other derivatives*, i.e. futures, and swaps (with the exception of the category "other"). However, Figure 1 cannot demonstrate the detail of the options markets; this is portrayed in Figure 2.

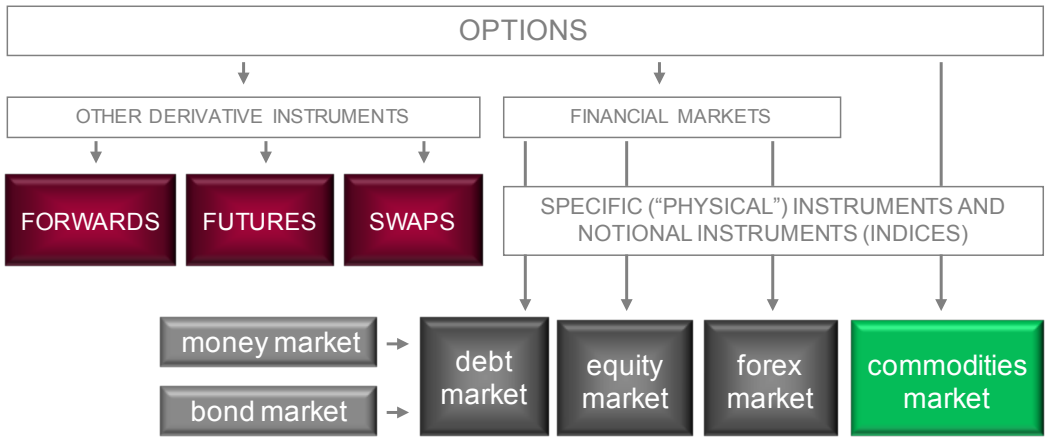

Figure 2: options

Figure 2 shows that there exist options on the derivatives futures and swaps (called swaptions), and that there are options on specific instruments and indices in the various financial markets and the commodity markets. These are covered in the following sections:

- The basics of options.
- Intrinsic value and time value.
- Option valuation and pricing.
- Organisation of options markets.
- Options on derivatives: futures.
- Options on derivatives: swaps.
- Options on debt market instruments.
- Options on equity / share market instruments.
- Options on foreign exchange.
- Options on commodities.
- Option strategies.
- Exotic options.

5.3 The basics of options

5.3.1 Definitions

An option bestows upon the holder the right, but not the obligation, to buy or sell the asset underlying the option at a predetermined price during or at the end of a specified period. Holders exercise their options only if it is rewarding to do so, and their potential profit is not finite, while their potential loss is limited to the premium paid for the option.

There are *two parties* to each option: the writer and the owner or holder. The writer grants the rights that the option bestows on the owner.

There are three *brands* of options, i.e. American, European and Bermudan:

- An American option bestows the right upon the holder to exercise the option at any time before and on the expiry date of the option.
- A European option gives the holder to exercise the option only on the expiry date of the option.
- A Bermudan option is an option where early exercise is restricted to certain dates during the life of the option. It derives its name from the fact that its exercise characteristics are somewhere between those of the American (exercisable at any time during the life of the option) and the European (exercisable only at the expiration of the option) style of options.

The majority of options traded locally and internationally are American options. It is to be noted that the three option brands do not refer to a geographic location. American and Bermudan options exist in Europe and European and Bermudan options can be found in America.

Options are classified as *call* options and *put* options:

- The *call* option bestows upon the purchaser the right to *buy* (think "call for…") the underlying asset at the pre-specified price or rate from the writer of the option.
- The *put* option gives the holder the option to *sell* the underlying asset at the pre-specified price or rate to the writer (think "put the writer with…").

The buyer pays the writer of the option an amount of money called the *premium*. It is called this because an option is much like an insurance policy.

Thus, there are *two sides* to every option contract (in the primary market):

- The buyer who has taken a *long position*, i.e. he has *bought* the option and has the benefits of the option (the "option" to do something). The buyer pays the premium for the option to the seller.
- The seller who has taken a *short position*, i.e. he has *sold* the option and received the premium (the seller has "no options" but is contracted to do something if the buyer decides to exercise the option). The *seller* of an option is the *writer* of the option.

The terms *long position* and *short position* applies to both puts and calls, i.e. one can have a *long put* and a *long call* (see below). It will be apparent that the writer's "position" is the reverse of that of the buyer of the option. If the writer does not have an offsetting position in the underlying market, he is said to be *naked* or *uncovered*. If the writer does then he is *covered*.

Options are said to be *in-the-money* (ITM), *at-the-money* (ATM) and *out-the-money* (OTM) (obviously from the point of view of the holder) as follows (in the case of *call* options):

- ITM: Price of underlying asset > strike price
- ATM: Price of underlying asset = strike price
- OTM: Price of underlying asset < strike price.

Another few parts of the definition require further illumination:

- underlying asset
- exercising
- exercise price
- expiration
- lapse.

Options are written on "something". This "something" is anything, i.e. options can be written on anything. As each house buyer and seller knows, the most common option is an option to buy a house. The seller of the house gives (writes) the option to the potential buyer of the house to buy the house at a *specified price* (exercise or strike price) during a specified period.

The house option is usually written free of charge (i.e. no *premium* is payable), and has a fixed term of a day or two or three. The holder of the option can *exercise* the option at any time between the time of the writing of the option and the *expiration* of the option at the *strike* (or *exercise) price* (i.e. specified price). The option *lapses* if the holder decides to not *exercise* his rights under the option. If the buyer exercises the option, the seller is *obliged* to do the deal, i.e. deliver the *underlying asset* (the house).

As seen earlier, the *underlying assets* in the options markets of the world are *other derivatives* (futures and swaps), and *specific instruments* ("physicals") and *notional instruments* (indices) of the various markets.

5.3.2 Payoff profiles

5.3.2.1 Introduction

There are 8 possibilities in terms of profit and/or losses when the price of the underlying asset changes (simple assumption: strike price = price of underlying). They are as shown in Table 1.

These payoff/loss profiles may be depicted as follows, but first we provide the assumptions:

Underlying commodity	= platinum
Contract	= 100 ounces
Strike price	= see diagrams below
Premium (option price)	= USD 10 per ounce (i.e. total of USD 1 000)
Option type	= European.

Position	Change in price of underlying asset	Profit or loss
Call option – buy *(long call)*	Fall	Loss: premium only
	Rise	Profit: unlimited
Call option – sell (write) *(short call)*	Fall	Gain: premium only
	Rise	Loss: unlimited
Put option – buy *(long put)*	Fall	Profit: unlimited
	Rise	Loss: premium only
Put option – sell (write) *(short put)*	Fall	Loss: unlimited*
	Rise	Gain: premium only
Note: these profiles only apply if strike price = price of underlying on deal day. * = unlimited up to the point where the underlying has no value.		

Table 1: Payoff profiles of writer and buyer

5.3.2.2 Call option: buy (long call) at expiry

The long call option is depicted in Figure 3[44]. If the price of platinum remains at USD 450 (per ounce[45]) or falls below USD 450 for the term of the option contract, the buyer will not exercise the option, because it is not profitable to do so. The option will lapse, and the buyer loses the premium amount USD 10 per ounce, i.e. USD 1 000 (USD 10 × 100). He cannot lose more than this amount.

If the price moves upwards to say USD 455 at the end of the life of the option, the holder will exercise the option because he will recover part of the premium paid, i.e. USD 500 (USD 5 × 100). The total loss of the holder of the option will be half the premium, i.e. USD 500.

It should be clear that the exercising of the option means that the writer delivers 100 ounces of platinum to the buyer for which the buyer pays USD 450 × 100 = USD 45 000. The total cost to the buyer / holder of the option now is USD 46 000 (USD 45 000 plus the USD 1 000 premium). The buyer / holder of the platinum now sells the platinum in the spot market at the spot market price of USD 455 and receives USD 45 500 (USD 455 × 100). The total loss is USD 500 (USD 46 000 – USD 45 500). If the holder does not exercise the option the loss is USD 1 000 (the premium).

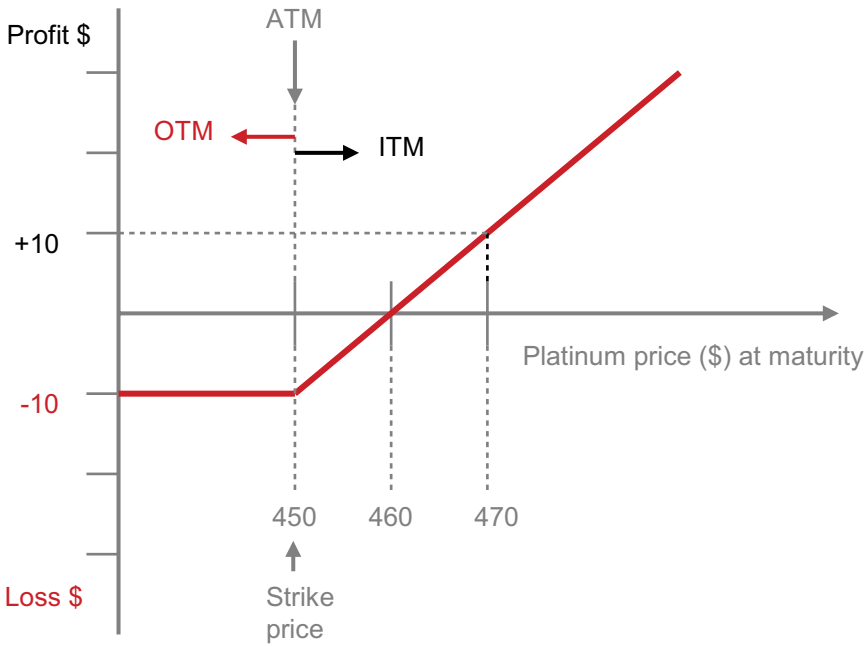

Figure 3: long call option

There are two other "options" for the buyer / holder in this regard:

- The holder could sell the option contract in the secondary market that exists for this paper. The value of the contract will be close to the market price of the underlying asset (pricing is discussed in some detail below).
- If the market is cash settled and the holder exercises, the writer pays the relevant amount to the holder (i.e. USD 500), and the writer's profit is USD 500.

If the spot platinum price moves to USD 460 (i.e. the strike price plus the premium) at the end of the life of the option, it also pays the holder to exercise the option because he will recover the premium paid. The option holder pays the writer USD 450 × 100 = USD 45 000, and sells the 100 ounces at the spot price of USD 460, i.e. for USD 460 × 100 = USD 46 000. The difference is USD 1 000 (USD 46 000 – USD 45 000), which is equal to the premium paid.

At any price above USD 460, there are 3 possibilities (that apply every day until expiry):

- Exercise the option.
- Sell the option.
- Keep the option (to expiry and exercise on expiry).

It will be apparent that the *profit potential of the holder is unlimited*. If say the platinum price moves to USD 600 and the holder exercises, the profit is:

Amount paid	= 100 × USD 450	= USD 45 000
Premium paid	= 100 × USD 10	= USD 1 000
Total cost		= USD 46 000
Amount sold for	= 100 × USD 600	= USD 60 000
Profit	= USD 60 000 – USD 46 000	= USD 14 000.

5.3.2.3 Call option: sell (write) (short call) at expiry

The short call option payoff profile is depicted in Figure 4. The payoff profile of the seller/writer of the call option is the reverse of that of the buyer. The maximum the seller can earn is USD 1 000, and the loss potential is unlimited. Thus, if the price at expiry is USD 450 or lower, he makes a profit of USD 1 000. At USD 460, the writer makes nothing, and at any price above USD 460, the writer makes a loss.

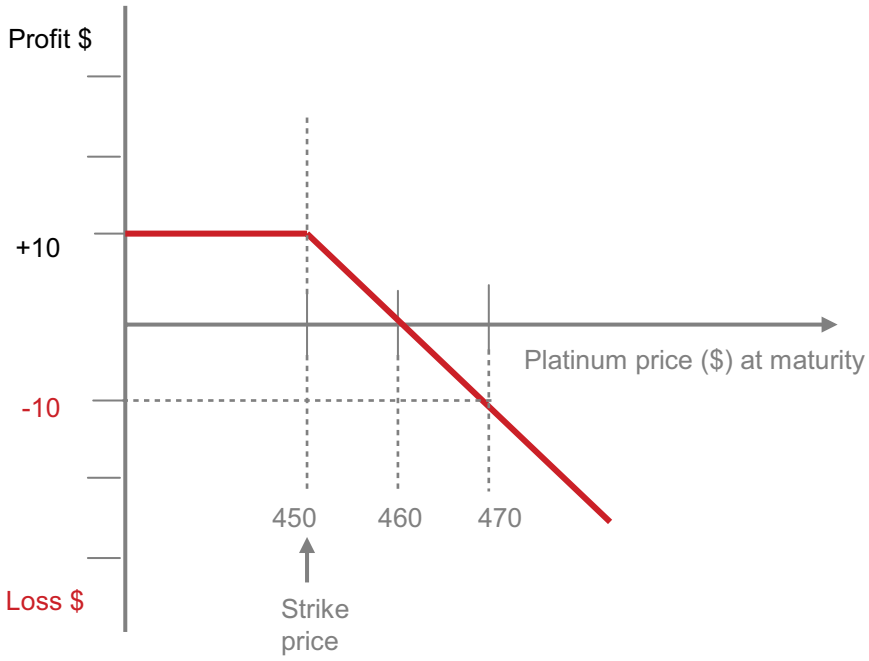

Figure 4: short call option

Some of the jargon referred to earlier is pertinent here. An *uncovered* or *naked short call* is where the writer does not have a position in the underlying instrument, i.e. is not holding the underlying instrument in portfolio (in this case 100 ounces of platinum). Where the writer does have a matching position in the underlying asset, he is *covered*, i.e. has a *covered short call*.

5.3.2.4 Put option: buy (long put) at expiry

The long put option payoff profile is depicted in Figure 5.

A put option is where the buyer has the right to "put" (sell to) the writer the underlying asset at a pre-specified price. In this example, the strike price is USD 470, and the buyer pays a premium of USD 1 000 (remember, USD 10 per ounce).

This is the mirror image of buying a call, i.e. the buyer is hoping for a fall in the price to make a profit. At a spot price of USD 470 or higher the buyer will allow the put option to lapse. At USD 460, the buyer breaks even and he will exercise the option before or at expiry in order to break even. At any price lower than USD 460 the buyer will make a profit.

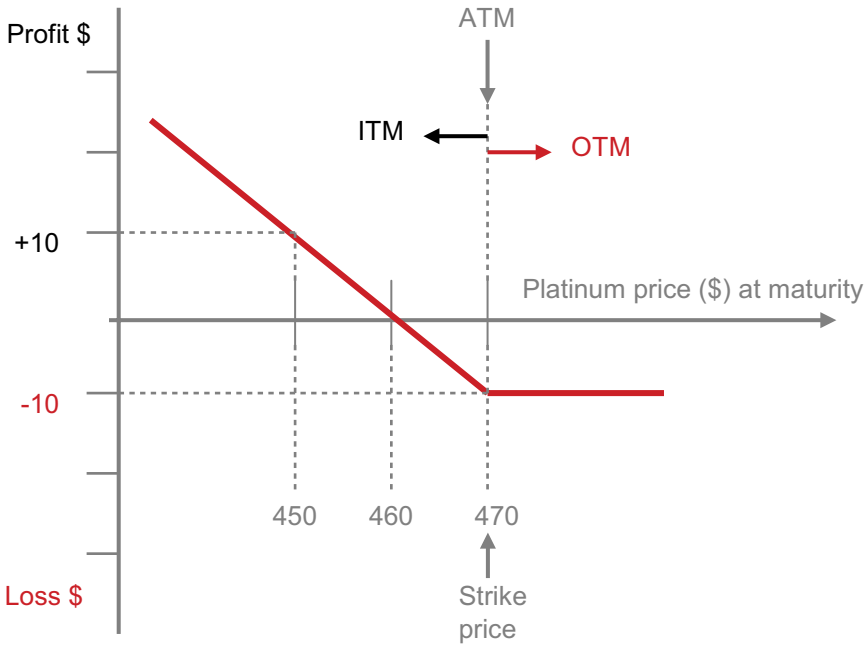

Figure 5: long put option

5.3.2.5 Put option: sell (write) (short put) at expiry

The short put option payoff profile is depicted in Figure 6.

At a spot platinum price of USD 470 or higher, the writer of a put option with a strike price of USD 470 will make a profit of USD 1 000 (i.e. the premium). At say USD 465 the profit will be halved because the buyer will exercise at expiry date). At any platinum price lower than USD 460, the writer's potential loss is unlimited (up to point where platinum price = 0).

5.4 Intrinsic value and time value

5.4.1 Introduction

The *price or premium* (P) of an option has two parts, i.e.:

- Intrinsic value (IV).
- Time value (TV).

Therefore:

$$P = IV + TV.$$

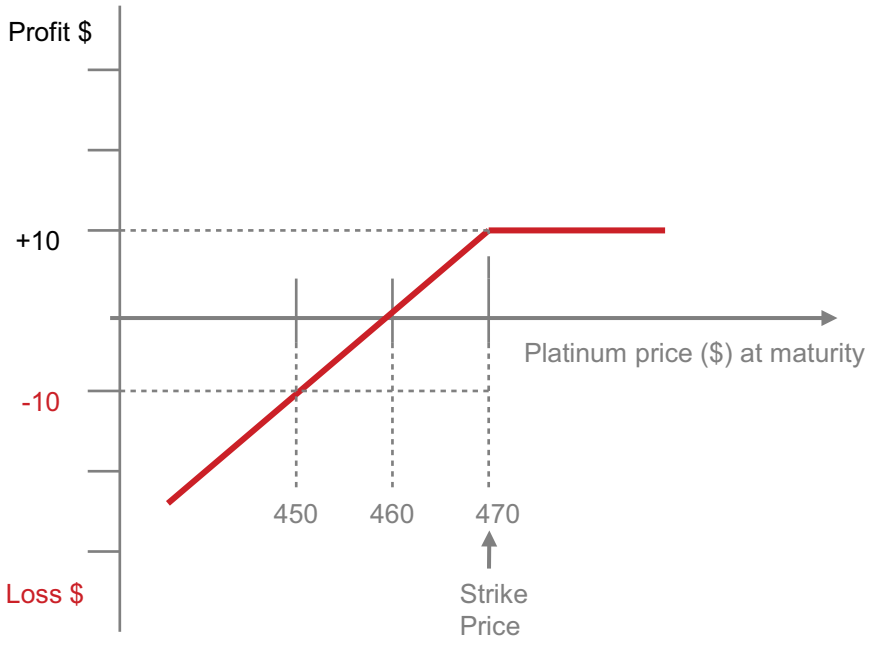

Figure 6: short put option

4.2 Intrinsic value

The difference between the *spot price of the underlying asset* (SP) and the *exercise price of the option* (EP) is termed the *intrinsic value* (IV) of the option.

As seen, there are 3 categories in this regard:

- In-the-money (ITM) options (have an intrinsic value)
- At-the-money (ATM) options (have no intrinsic value)
- Out-the-money (OTM) options (have no intrinsic value).

ITM options are:

- Call options where: SP > EP
- Put options where: SP < EP.

Clearly, the following options have no intrinsic value (OTM):

- Call options where: SP < EP
- Put options where: SP > EP
- Call options where: SP = EP
- Put options where: SP = EP.

Thus:

IV = SP – EP (call options); positive when SP > EP
IV = EP – SP (put options); positive when EP > SP.

A summary is provided in Table 2.

ITM / ATM / OTM	Call options		Put options	
ITM	SP > EP	IV > 0	SP < EP	IV > 0
ATM	SP = EP	IV = 0	SP = EP	IV = 0
OTM	SP < EP	IV = 0	SP > EP	IV = 0

Table 2: Payoff profiles: ITM, ATM and OTM options

5.4.3 Time value

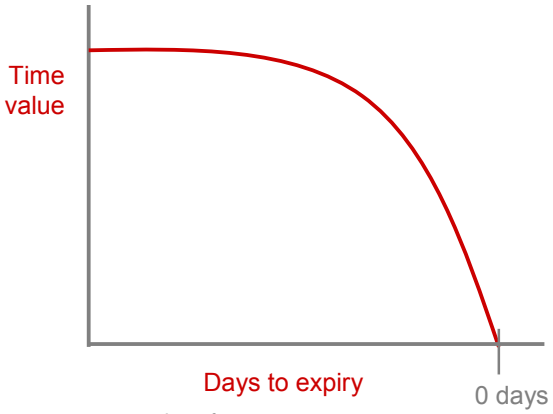

Figure 7: time value of option

The *time value* (TV) of an option is the difference between the *premium* (P) of an option and its *intrinsic value* (IV):

P = IV + TV
TV = P – IV.

An example is required:

Option		= call option
Underlying asset		= ABC share
Underlying asset spot market price (SP)		= LCC 70
Option exercise price (EP)		= LCC 60
Intrinsic value (IV)	= SP – EP = IV	= LCC 70 – LCC 60 = LCC 10
Premium (P)		= LCC 12
Time value (TV)	= P – IV = TV	= LCC 12 – LCC 10 = LCC 2.

The option has *time value* of LCC 2, and this indicates that there is a *probability that the intrinsic value could increase between the time of the purchase and the expiration date*. If the option is exercised now (i.e. at LCC 60), the intrinsic value is gained, *but time value is forgone*. It will be apparent that as an option moves towards the expiration date, time value diminishes, and that at expiration time value is zero. This is portrayed in Figure 7.

5.5 Option valuation/pricing

5.5.1 Introduction

There are two main option pricing / valuation models that are used by market participants:

- Black-Scholes model.
- Binomial model.

Below we also mention the other pricing models and define the so-called "Greeks".

5.5.2 Black-Scholes model

5.5.2.1 Introduction

The Black-Scholes model was first published in 1973 and essentially holds that the fair option price (or premium) is a function of the probability distribution of the underlying asset price at expiry. It has as its main constituents the following (see the valuation formula below)[46]:

- Spot (current) price of underlying asset (assume share) (SP).
- Exercise (strike) price (EP).
- Time to expiration.
- Risk free rate (i.e. treasury bill rate).
- Dividends expected on the underlying asset during the life of the option.
- Volatility of the underlying asset (share) price.

Each of these elements is covered briefly below.

5.5.2.2 Spot (current) price of underlying asset and exercise price

If a call option is exercised the *profit* is:

SP – EP (obviously if SP < EP, there is no profit).

Call options are therefore more valuable as the SP of the underlying asset *increases* (EP a given) and less valuable the higher EP is (SP a given). The opposite applies in the case of put options. The profit on a put option if exercised is:

EP – SP (obviously if EP < SP there is no profit).

Put options are therefore more valuable as the SP of the underlying asset *decreases* (EP a given) and less valuable the lower EP is (SP a given).

5.5.2.3 Time to expiration

The longer the time to expiration the more valuable both call and put options are. The holder of a short-term option has certain *exercise opportunities*. The holder of a similar long-term option also has these opportunities and more. Therefore the long option must be at least equal in value to a short-term option with similar characteristics. As noted above, the longer the time to expiration the higher the probability that the price of the underlying assets will increase/decrease.

5.5.2.4 Risk free rate

The risk free rate (rfr) is the rate on government securities. The effect of the rfr on option prices is not as clear-cut as one would expect. As the economy expands, rates tend to increase, but so does the expected rate of share price increases, because dividends increase. It is also known that the present value of future cash flows also decreases as rates increase.

These two effects tend to reduce the prices of put options, i.e. the value of put options decreases as the rfr increases. However, it has been shown that the value of call options increase as the rfr increases, as the former effect tends to dominate the latter effect.

5.5.2.5 Dividends

Dividends have the effect of reducing the share price on the ex-dividend date. This is positive for puts and negative for calls. The size of the expected dividend is important, and the value of call options is therefore negatively related to the size of the expected dividend. The opposite applies to put options.

5.5.2.6 Volatility

Of these factors, the only one that is *not observable* is *volatility*, i.e. the extent of variance in the underlying asset price. This is estimated (calculated) from data in the immediate past.

It will be clear that as volatility increases, so does the chance that the share will do well or badly. The investor in a share will not be affected because these two outcomes offset one another over time. However, in the case of an *option holder* the situation is different:

- The call option holder benefits as prices increase and has limited downsize risk if prices fall.
- The put option holder benefits as prices decrease and has limited downsize risk if prices rise.

Thus, both puts and calls increase in value as volatility increases.

5.5.2.7 The model

The Black-Scholes valuation model is as follows (European call option):

$$P_c = N(d_1)S_0 - E(e^{-rt})N(d_2)$$

where

P_c = price of European call option
S_0 = price of the underlying asset currently
E = exercise price of the option
e = base of the natural logarithm, or the exponential function
r = risk-free rate per annum with maturity at expiration date
N(d) = value of the cumulative normal distribution evaluated at d_1 and d_2
t = time to expiry in years (short-term = fraction of a year)
$d_1 = [\ln(S_0/E) + (r + \sigma^2/2)t] / \sigma\sqrt{t}$
$d_2 = d_1 - \sigma\sqrt{t}$
ln = natural logarithm (Naperian constant = 2.718)
σ^2 = variance (of price of underlying asset on annual basis)
σ = standard deviation (of price of underlying asset on annual basis).

In the case of a European put option, the price formula changes to:

$$P_p = - E(e^{-rt})N(-d_2) - N(-d_1)S_0.$$

The one parameter of the model that cannot be directly observed is the *price volatility* of the underlying asset (standard deviation). It is a measure of the uncertainty in respect of returns on the asset. According to research, typically, volatility tends to be in the range of 20–40% pa. This can be estimated from the history of the assets. An alternative approach is *implied volatility*, which is the volatility implied by the option price observed in the market.[47]

Implied volatilities are used to gauge the opinion of market participants about the volatility of a particular underlying asset. Implied volatilities are derived from actively traded options and are used to make comparisons of option prices.

The Black-Scholes option pricing model is not the Midas formula, because it rests on a number of simplifying assumptions such as the underlying asset pays no interest or dividends during its life, the risk-free rate is fixed for the life of the option, the financial markets are efficient and transactions costs are zero, etc. However, it is very useful in the case of certain options (see section on binomial model after the following section). Next we present an example.

5.5.3 Example of black-scholes option pricing

The underlying asset is a non-dividend-paying share of company XYZ the current share price of which is LCC 100. The option is a European call, its exercise price is LCC 100 and it has a year to expiry. The risk-free rate is 6.0% pa, historical volatility is 30% and the standard deviation of the share's returns is 0.1 per year. Thus:

S_0 = LCC 100
E = LCC 100
r = 0.06
t = 1

$\sigma^2 = 0.01$

$\sigma = 0.1$

$$d_1 = [\ln(S_0/E) + (r + \sigma^2/2)t] / \sigma\sqrt{t}$$
$$= [\ln(100/100) + (0.06 + 0.005)1] / 0.1\sqrt{1}$$
$$= 0.065 / 0.1$$
$$= 0.65.$$

From the cumulative normal distribution table[48] one can establish the value of $N(d_1)$:

$$N(d_1) = N(0.65) = 0.7422.$$

Similarly we find the value of $N(d_2)$:

$$d_2 = d_1 - \sigma\sqrt{t}$$
$$= 0.65 - 0.1$$
$$= 0.55$$
$$N(d_2) = (0.55) = 0.7088 \text{ (from table).}$$

We are now able to complete the model:

$$P_c = N(d_1)S_0 - E(e^{-rt})N(d_2)$$
$$= (0.7422 \times \text{LCC } 100) - (\text{LCC } 100 \times 2.718^{-0.06\times1} \times 0.7088)$$
$$= \text{LCC } 74.22 - (\text{LCC } 100 \times 0.94177 \times 0.7088)$$
$$= \text{LCC } 74.22 - \text{LCC } 66.75$$
$$= \text{LCC } 7.47.$$

5.5.4 Binomial model

The Black-Scholes model is regarded as a good valuation model for certain options, particularly for European options on commodities. However, it is regarded as less accurate for dividend paying options and particularly so if the option is of the American variety. Also, it tends to undervalue deep-in-the-money options. Another problem is the assumption of log normality of future asset prices.

Where the Black-Scholes is regarded as weak, the binomial model is used. This model involves the construction of a *binomial tree*, i.e. a diagram representing different possible paths that may be followed by the underlying asset over the life of the option.

5.5.5 Other models

In addition to these two valuation models, there are:

- Monte Carlo simulation.
- Finite difference methods (implicit finite difference method and explicit finite difference method).

5.5.6 The Greeks

In the derivative markets reference is often made to the Greek letters, known as the "Greeks". The "Greeks" measure different dimensions of risk in option positions as follows:[49]

Delta

The *delta* is the rate of change of the option price with respect to the price of the underlying asset.

Theta

The *theta* of a portfolio of derivatives is the rate of change of the portfolio value with respect to the passage of time (*ceteris paribus* – when all else remains the same). It is often referred to as the *time decay* of the portfolio.

Gamma

The *gamma* of a portfolio of derivatives on an underlying asset is the rate of change of the portfolio's *delta* with respect to the price of the underlying asset.

Vega

The *vega* of a portfolio of derivatives is the rate of change of the value of the portfolio with respect to the volatility of the underlying asset.

Rho

The *rho* of a portfolio of derivatives is the rate of change of the portfolio value with respect to the interest rate.

5.6 Organisational structure of option markets

One way of depicting the organisational structure of option markets is as in Figure 8.

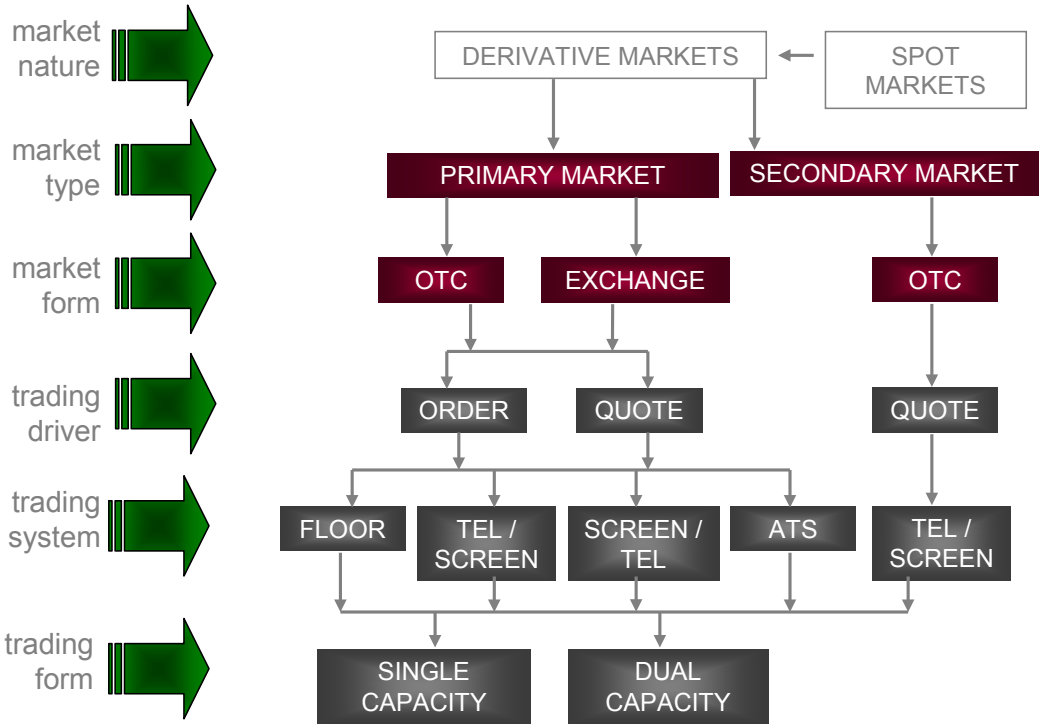

Figure 8: organisation of options markets

The *market form* of options is a mixture of *formal* in the shape of an exchange where options are listed, and *OTC*. There are many futures / options exchanges in the world, or futures / options divisions of exchanges. There are also substantial OTC markets.

As to whether option markets are *primary markets* and/or *secondary markets*, the answer depends on whether they are OTC or exchange-traded. In the case of the OTC markets, there are primary markets in which options are issued and secondary markets in which existing options can be sold and bought. In the case of exchange-traded options the primary and secondary markets are "merged". They are issued by the exchange (primary market) and can be "sold" ("closed out") in the sense of dealing in the opposite direction. For example, if a client has bought a call option, she can close out the position by selling the same call option. However, the holder/ buyer of an option has other alternatives: exercise the option (if it is an American option and has value), or letting it expire worthless on expiration date.

The main advantage of exchange-traded options is that they are guaranteed by the exchange, they are standardised and they are (usually) liquid markets. The main advantage of the OTC market is that the options are customised. The differences between these two markets are as shown in Table 3.

	OTC	Exchange-traded
Regulation	None	Yes
Contracts	Usually not standardised (standardised in certain respects)	Standardised
Margin	Sometimes	Yes
Delivery dates	Customised (large range)	Standardised (limited range)
Delivery of underlying instrument	Almost always	Few settled by delivery
Instruments	Virtually all	Virtually all
Secondary market tradability	Limited	Liquid secondary markets
Participants	Large players only	Large and small players
Risk	Deal between counterparties – each faces risk	Contracts guaranteed by exchange
Market	Screen or telephone or both	Open outcry on exchange floor, or telephone or ATS

Table 3: Comparison of otc and formalised options markets

The *trading-driver* process of *listed* options is the same as in the case of listed futures. The client telephones the broker and places an *order* to sell or buy a particular number of call or put options. She will of course also state the expiration date/s and strike price/s. The order placed is either a *market order* or a *limit order*. The former is an instruction to deal at the best available price, while the latter is an order to transact at a specific price.

In most listed options markets this information will be inputted into the *ATS system* and left there until a match is found (which in most markets is usually a few seconds or minutes because these markets are so liquid). In the case of an open outcry system of trading (as in certain overseas markets), the order is communicated to the trader in the pit. Traders form groups reflecting the various delivery dates. The order is "cried out" and another trader "cries out" if she has an opposite matching order. The trade is done with a floor broker, a market maker or a professional trader.

In OTC markets the *method of trading* is screen / telephone or just telephone, and the *trading driver is quote*. Certain broker-dealers quote option buying and selling prices (premiums). Settlement takes place on T+1 or T+2.

It will be apparent that not just anyone is able to trade in the OTC market, and this is because each party is directly exposed to the other party in terms of risks such as settlement risk, risk of tainted scrip, default risk, etc. One needs credentials and a track record to deal in the OTC options markets.

5.7 Options on derivatives: futures

5.7.1 Introduction

The options market overview illustration is reproduced here for the sake of orientation (see Figure 9).

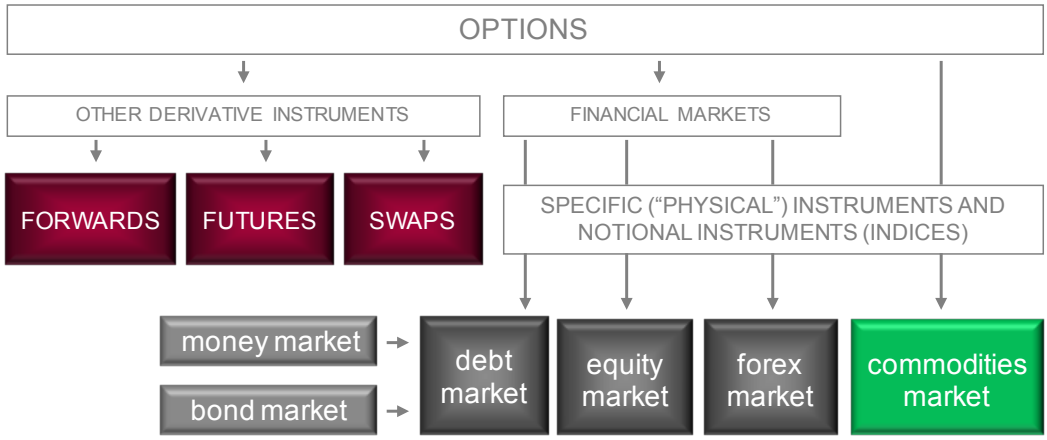

Figure 9: options

As noted, all futures markets are formalised markets. Options are available on virtually all futures, and most of these options are exchange-traded. The word "most" is used here because in some markets *OTC options on futures* also exist.

With options on futures (also called "futures options") the *underlying instrument is a futures contract* (not the underlying instrument of the future). The relevant price is therefore the price of the futures contract (and not the price of the underlying instrument or index). The futures contract usually matures a short while after the expiration of the futures option. When the holder of a call futures option *exercises* the option, the *writer is obligated to deliver* to the holder of the option:

- A long position in the underlying futures contract.
- Plus an amount that is equal to the difference between the last MTM[50] futures price and the exercise price (futures price – exercise price).

Conversely, when the holder of a put on a future *exercises* the option, the *writer is obligated to deliver* to the holder of the put:

- A short position in the underlying futures contract.
- Plus an amount that is equal to the difference between the exercise price and the last MTM futures price (exercise price – futures price).

In practice, however, most options on futures are settled in cash.

It will be recalled that the futures market may be categorised (with examples included) as shown in Table 4.

FINANCIAL			COMMODITIES	
Interest rate	Equity / share	Foreign currencies	Agricultural	Metals and energy
Physical Treasury bonds Treasury notes Treasury bills Federal funds Canadian govt bond Eurodollar Euromark Euroyen Eurobond **Index (notional)** Short sterling bond index Long sterling bond index Municipal bond index	**Physical** Various specific shares **Index (notional)** DJ Industrial S&P 500 NASDAQ 100 CAC-40 DAX-30 FTSE 100 Toronto 35 Nikkei 225 NYSE	**Physical** Japanese yen DM British pound Swiss franc French franc Australian dollar Brazilian real Mexican peso Sterling/mark cross rate **Index (notional)** US dollar index	**Grains and oilseeds** Wheat Soybeans Corn (maize) **Livestock and meat** Cattle – live Hogs – lean Pork bellies **Food and fibre** Cocoa Coffee Sugar Cotton Orange juice	**Physical -Metals** Gold Platinum Silver Copper Aluminium Palladium **Physical -Energy** Crude oil – light sweet Natural gas Brent crude Propane **Index (notional)** CRB index
Physical = the actual instrument, currency, commodity. Index = indices of exchanges, etc. CRB index = Commodity Research Bureau.				

Table 4: Examples of futures contracts

As noted, options are available on virtually all futures. In the US the most active options on futures contracts are the options on treasury bond futures and treasury note futures, options on the Eurodollar futures, and options on the futures contracts on corn, soybeans, and crude oil.

It may be useful to provide an example of an option on futures deal:

5.7.2 Example

An investor requiring a general equity / share exposure to the extent of LCC 1 million decides to acquire this exposure through the purchase of call options on the All Share Index (ALSI) future. If the index is currently recorded at 5 000, she would require 20 call option contracts (20 × LCC 10 × 5000 = R1 000 000) (remember that one ALSI futures contract is equal to LCC 10 times the index value).

Because the investor is buying the *right* to purchase the future and has *no obligation* in this regard, she pays a premium to the writer. In this example we make the assumption that the premium is LCC 1 500 per contract (LCC 30 000 for 20 contracts). The investor is thus paying LCC 30 000 for the right to purchase 20 ALSI futures contracts at an exercise or strike price of 5000 on or before the expiry date of the options contract.

It will be evident that the premium per contract of LCC 1 500 translates into 150 points in the all share index (LCC 1 500 / LCC 10 per point). Thus, the investor's *breakeven price* is 5150 (5000 + 150). This can be depicted as the plum-coloured line in the payoff diagram shown in Figure 10.

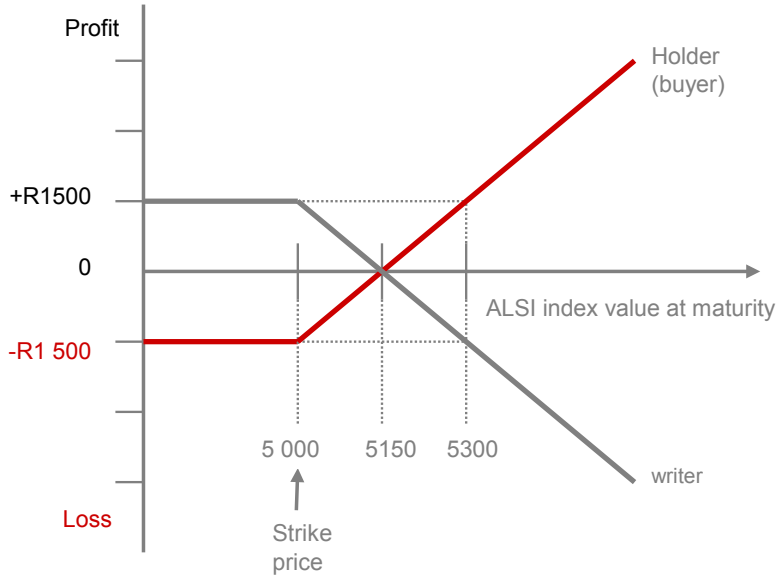

Figure 10: payoff profile of writer and holder of call option

Assuming that the buyer (investor) holds the contracts to expiry:

- If the price closes at or below 5000 she will not exercise. She incurs a loss equal to the premium paid, i.e. LCC 1 500 per contract.
- If the price closes between 5000 and 5150 she will exercise the options and recover a portion of the premium.
- If the market closes at a price above 5150 she will exercise and make a profit. For example, if the price at expiry is 5400, her profit is LCC 2 500 per contract [i.e. LCC 10 × (5400 – 5150)].

The risk profile of the writer is exactly the reverse of that of the holder. As can be seen in Figure 10:

- The writer makes a profit of LCC 1 500 (the premium) per contract if the price closes at or below 5000.
- The writer makes a profit of less than LCC 1 500 per contract if the price closes at between 5000 and 5150. This is because the holder will exercise between these two prices in order to recover a portion of her premium.
- The writer makes a loss if the price rises above 5150. For example, if the price closes at 5600, the writer will make a loss of LCC 4 500 [LCC 10 × (5600 – 5150)] per contract.

It will be apparent that the investor gained her LCC 1 million exposure with a monetary outlay of LCC 30 000. Thus, she is able to invest the balance of LCC 970 000 in the money market and receive the current interest rate. The money market rate (rfr) is thus an important input in the pricing of options (as seen above).

Figure 11: payoff profile of writer and holder of call option

The buyer of a put option has a risk profile which is the converse of that represented by a call option (see Figure 11). For example, an investor wanting to hedge his LCC 1 million equity / share exposure (i.e. anticipating that share prices will fall) would buy 20 put option contracts on the ALSI future (assuming the strike price to be 5000). She is thus hedged to the extent of LCC 10 × 20 × 5000 = LCC 1 000 000. She thus has the right, but not the obligation, to sell to the writer (seller) 20 ALSI futures contracts on or before the expiry date of the options contracts. Assuming that the premium paid is LCC 1 500 per contract, her risk profile is as depicted in Figure 11.

As far as the holder is concerned:

- If the price closes at 5000 or higher, she will not exercise and the loss is limited to LCC 1 500 per contract.
- If the price closes at between 5000 and 4850, she will exercise and recover a portion of the premium.
- If the price falls below 4850 she makes a profit equal to LCC 10 per point per contract.

Conversely, the writer of the put options will profit to the extent of LCC 1 500 per contract if the price at close is 5000 or better, profit less than LCC 1 500 at a price between 4850 and 5000 and incur a loss at a price below 4850 to the extent of LCC 10 per point per contract.

Options on futures are also subject to margin requirements. These are the same as for the underlying futures.

5.7.3 Option specifications

As will be understood, options contracts take on many of the features of the underlying instruments, i.e. the futures contracts. The below-mentioned option specifications should therefore be read together with the futures contract specifications (see Table 6[51]).

The two basic uses of options on futures are to protect a future investment's return from falling interest rates / rising prices (call option), and to protect against rising interest rates / falling prices (put options).

Expiry	The same time and date as the underlying futures contract
Style	American
Types	Both a call and a put at each strike (exercise)
Strike price units	Strike prices are specified in the units of quotation of the underlying futures contract
Strike price intervals	Strike prices are at fixed intervals.
Live strikes	Three strike prices are "live", i.e. are accommodated on the screens. The corresponding options are "at", "in" and "out" of the money, and are referred to as "strike 1", "strike 2" and "strike 3" on the screens. A separate screen gives the value of the strike price associated with each of the three.
Strike shifts	The live strikes are shifted, and new strikes introduced (if necessary) whenever the underlying financial instrument's price: • Moves beyond either of the away-from-the-money strikes or • Is consistently closer to an away-from-the-money strike than to the at-the-money strike for one trading day. Shifts are not normally more frequent than daily, and are made overnight. All shifts are made at the exchange's discretion.
Free-format screens	Quotations for options whose strike prices are not live are entered onto one or more free-format screens
Contract size	Each option is on *one* contract of its underlying financial instrument
Standard lot size	(Number of options that quotations are good for). The same as the underlying financial instrument's standard lot size.
Quotations	Quotations are in whole rands per option
Settlement of premiums	Through the mark to market process over the life of the option
Mark-to-market	Daily according to the option's mark to market price (i.e. the same as for futures)
Determination of mark to market prices	• Quoted doubles are used where available • Implied volatilities are calculated from available prices to value options (on the same underlying financial instrument) lacking quotes • Exchange has the discretion to override the former and to specify volatilities overriding the latter
Exercise	May be exercised at any time until expiry. A client's option is exercised through his member directly with the exchange
Settlement on exercise	Into the underlying financial instrument
Assignment	Options exercised will be randomly assigned to short positions in the same option. Assigned holders (or their members), and their clearing members, will be notified immediately. Assignment will be in standard lot sizes as far as possible.
Automatic exercise	All in-the-money options will be automatically exercised (into the underlying financial instrument) on expiry. This happens before the close out by the exchange of positions in futures contracts.
Margins	Option positions are subject to the same initial margin requirements as their underlying financial instruments. However, the potential profit/loss profile of options is recognised. Margins are also affected by volatility margin requirements.
Source: Safex / JSE.	

Table 6: Option specifications

5.8 Options on derivatives: swaps

Figure 12 is presented here for the sake of orientation. We discussed *swaps* in some detail in a previous section. An option on this derivative is the *option on the swap*, called the *swaption*.

We saw earlier that there are four types of swaps that relate to the financial markets and the commodity market (see Figure 13). We also saw that there exists a *forward swap* (or deferred swap) (it is mentioned here again because it is touched upon below).

Options are not found on all these swaps, but only on the *interest rate swap*, i.e. a *swaption* is a *combination of an interest rate swap and an option*. As elucidated above, in interest rate swaps, fixed-rate obligations (cash flows) are swapped for floating rate obligations. In swaptions, the underlying instrument is the *fixed-rate* obligation. Thus, a *call swaption imparts the right to the holder to receive the fixed rate in exchange for the floating rate, while in put swaptions the holder has the right to pay fixed and receive floating.*

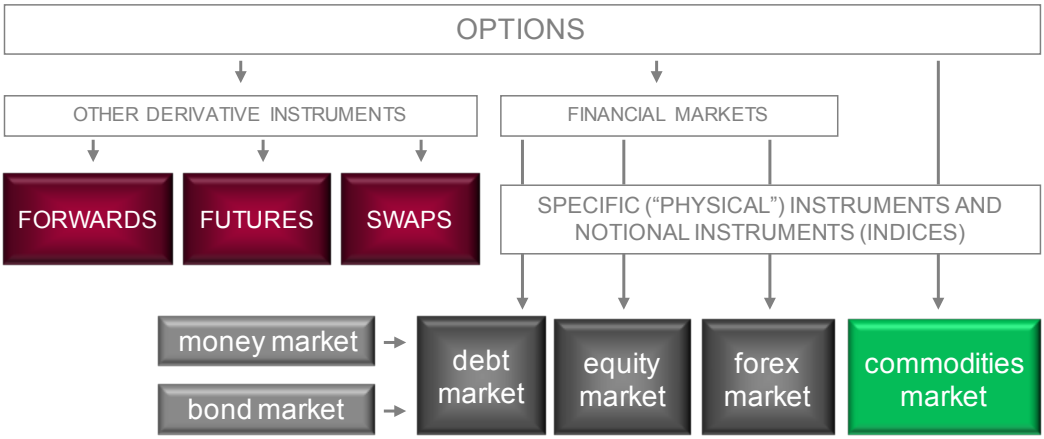

Figure 12: options

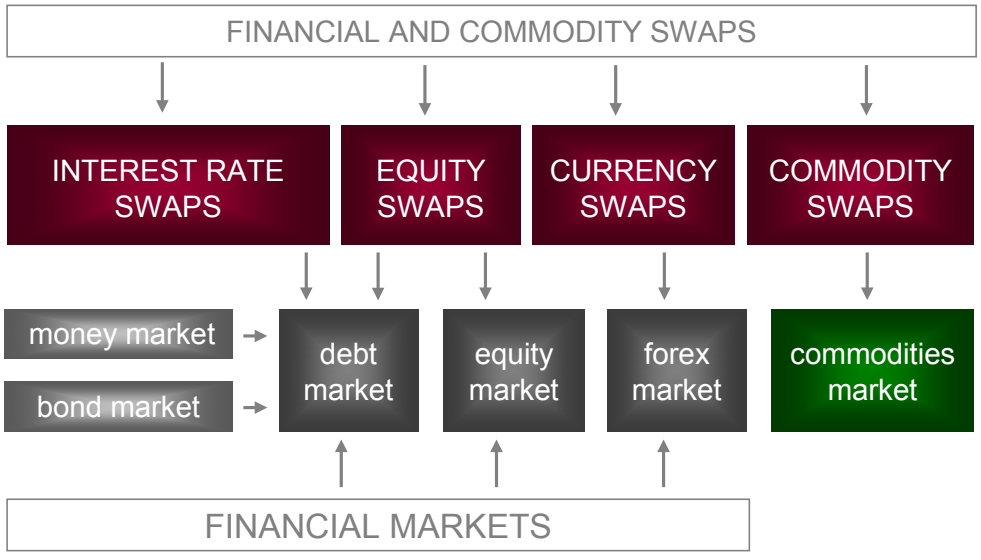

Figure 13: swaps

An example may be useful.[52] A company knows that in six months' time it is to enter into a five-year floating rate loan (i.e. borrowing) agreement at 3-month JIBAR, and wants to swap the floating rate payments into fixed rate payments, i.e. to convert the loan into a fixed rate loan (because the company believes that rates are about to rise).

For a premium, the company can buy a (put) swaption from a broker-dealer in this type of paper. The swaption gives the company the right to receive the 3-month JIBAR rate on a notional amount that is equal to its loan, and to pay a fixed rate of interest every three months at 14% pa (assumed) for the next five years, starting in six months' time. The "options" the company has are clear:

- If in six months time the fixed rate on a normal 5-year swap is lower than 14%, the company will allow the swaption to lapse (remember the company wants to pay fixed).
- The company will then undertake a normal interest rate swap at the lower fixed rate (the floating rate will probably still be 3-month JIBAR).
- If the fixed rate on normal swaps is higher than 14%, the holder will exercise the swap and take up the swap.

The company is guaranteed that the fixed rate it will pay on the future will not exceed an agreed fixed rate. Thus the company has protection against rates moving up, while retaining the option to benefit from lower rates in the future.

The swaption is an *alternative* to the *forward swap*. The latter obliges the holder to enter into a swap after a stipulated period, but the holder pays no premium for it. In the case of the swaption, the holder is not obligated and can allow the swaption to lapse, i.e. it allows the holder to benefit from favourable interest rate movements.[53]

5.9 Options on debt market instruments

5.9.1 Introduction

The options market illustration presented here again is designed to orientate the reader in terms of the place of the market being discussed (see Figure 14).

The term "debt market instruments" in respect of options encompasses money and bond market *specific instruments* ("physicals") (or rather some of them) and *notional instruments* (indices) (or some of them). They may be classified as follows:

- Money market options:
  - Options on specific money market instruments.
  - Interest rate caps and floors.
- Bond market options:
  - Options on specific bonds.
  - Options on bond indices.
  - Bond warrants (retail options).
  - Bond warrants (call options).
  - Callable and puttable bonds (bonds with embedded options).
  - Convertible bonds.

Money market options are comprised of options on specific money market instruments (and this includes ordinary deposits) and caps and floors (these are *option-like* instruments). As seen in the list, there are a number of bond option varieties. The first three mentioned above are full-blooded bond options, while the latter three may be termed *option-like securities* in the bond market. We discuss all these a little later. Options on *bond futures* are obviously not discussed in this section (they were discussed under "options on derivatives").

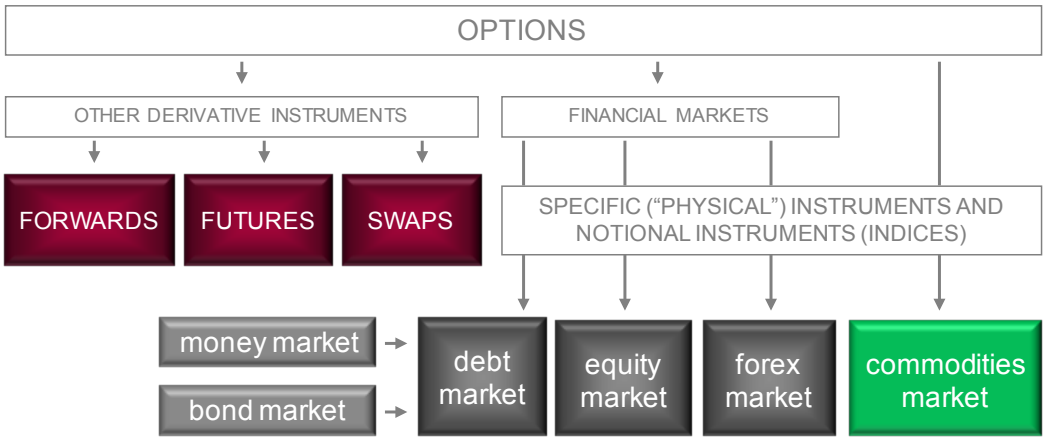

Figure 14: options

5.9.2 Options on specific money market instruments

Money market options are options that are written on specific money market instruments, such as commercial paper, NCDs, deposits, etc. Not many countries have specific asset money market options, because of the existence of the active markets in other money market derivatives (swaps, swaptions, repos, caps and floors, FRAs, and interest rate futures).

Some countries, however, have options on *notional* money market instruments. A UK example is presented in Table 8.[54]

Let us focus in on the June call option at a strike (exercise) price of 9350, and a premium of 0.09. What do these numbers mean? The holder of the option has the right to make a deposit of GBP 500 000 on the expiry date in June (the date is specified) at an interest rate of 6.5% (100 – 93.50) for 3 months. Each tick movement on the contract, which is equivalent to one basis point, is worth the value of the contract (GBP 500 000) multiplied by 1 basis point (0.01% or 0.0001) and a quarter of a year (0.25), i.e.:

$$\text{GBP } 500\,000 \times 0.0001 \times 0.25 = \text{GBP } 12.50.$$

Strike price	Calls			Puts		
	Dec	Mar	Jun	Dec	Mar	Jun
9350	0.11	0.08	**0.09**	0.06	0.33	0.66
9375	0.01	0.02	0.04	0.21	0.52	0.86
9400	0.00	0.01	0.02	0.45	0.76	1.09

Table 8: Example of option on money market instrument

The cost of the call option (i.e. the premium) is therefore 9 × GBP 12.50 = GBP 112.50.

If by the expiry date the contract strike price rises to 9450 (interest rates have fallen to 5.5%) the holder is entitled to a gain of 100 basis points, and the profit is 100 × GBP 12.50 = GBP 1 250.00 less the premium of GBP 112.50 = GBP 1 137.50.

On the other hand, if interest rates have risen (to 7% pa) so that the contract is trading at 9300, the contract will not be exercised and the holder will forego the premium of GBP 112.50.

5.9.3 Caps and floors

5.9.3.1 Description

Caps and *floors* (a combination of which is termed a *collar*) are akin to options. In fact they are so similar to options that they could be termed *cap options* and *floor options*. Because of their option-like attributes, they are placed in this section on options.

A *cap* purchased makes it possible for a company with a *borrowing requirement* to hedge itself against *rising interest rates*. The cap contract establishes a ceiling, but the company *retains the right to benefit from falling interest rates*. On the other hand, a *floor* contract allows a company with an *investment requirement* (surplus funds) to shield itself against *declining interest rates* by determining a specified floor upfront, while it *retains the right to profit from rising interest rates*.

On the *exercise date* of the cap or floor contract, the specified *strike rate* is evaluated against the *standard reference rate* (i.e. usually the equivalent-term JIBAR rate). The interest differential is then applied to the *notional principal amount* that is specified in the contract, and the *difference is paid* by the seller/writer to the buyer/holder. The buyer of a floor or cap pays a *premium* for the contract, as in the case of an option or insurance policy.

5.9.3.2 Caps

It is perhaps best to elucidate a cap with the assistance of an example: *borrowing company buys a T3-month – T6-month cap* (see Figure 15).

A company needs to borrow LCC 20 million in 3 months' time for a period of 3 months, and is *concerned that interest rates are about to rise sharply*. The present 3-month market rate (JIBAR[55] rate = market rate) is 10.3% pa. The company is quoted a T3-month – T6-month (T3m-T6m) cap by the dealing bank at 10.5%, i.e. the 3-month JIBAR borrowing rate for the company is fixed 3-months ahead. The company accepts the quote and pays the premium of LCC 25 000 to the dealing bank. The number of days of the period for which the rate is fixed is 91.

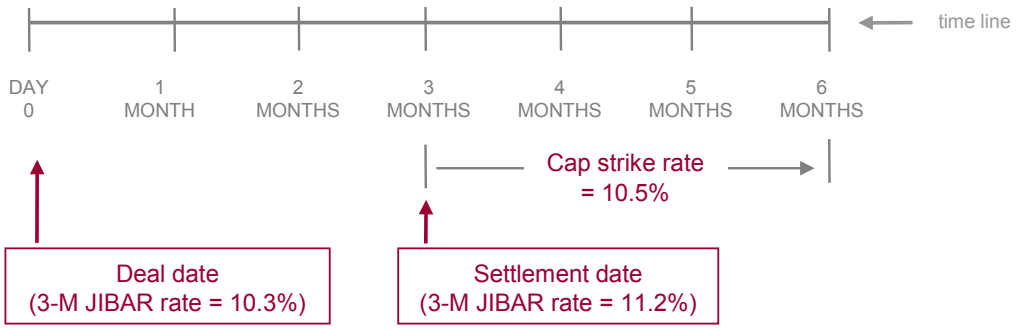

Figure 15: example of T3-month – T6-month cap

If the JIBAR rate (= market rate on commercial paper, the borrower's borrowing habitat) in 3-months' time (i.e. settlement date), is 9.3%, the company will allow the cap to lapse (i.e. will *not exercise the cap*) and instead will borrow in the market at this rate by issuing 91-day commercial paper. The total cost to the company will be the 9.3% interest *plus the premium paid* for the cap:

$$\text{Cost to company} = (C \times ir \times t) + P$$

where

C = consideration (amount borrowed)
ir = interest rate (expressed as a unit of 1)
t = term, expressed as number of days / 365
P = premium

Cost to company = (C × ir × t) + P
= LCC 20 000 000 × 0.093 × 91 / 365) + LCC 25 000
= LCC 463 726.03 + LCC 25 000
= LCC 488 726.03.

It will be apparent that the interest rate actually paid by the company (ignoring the fact that the premium is paid upfront) is:

Total interest rate paid = LCC 488 726.03 / LCC 20 000 000 × 365 / 91
= 0.0244363 × 4.010989
= 0.09801
= 9.80% pa.

If the JIBAR rate on the settlement date is say 11.2% pa, settlement will take place with the dealing bank according to the following formula:

SA = NA × [(rr – csr) × t]

where

SA = settlement amount
NA = notional amount
rr = reference rate
csr = cap strike rate
t = term, expressed as number of days / 365

SA = LCC 20 000 000 × [(0.112 – 0.105) × 91 / 365]
= LCC 20 000 000 × (0.007 × 91 / 365)
= LCC 34 904.11.

The financial benefit to the company is equal to the settlement amount minus the premium:

Financial benefit = SA – P
= LCC 34 904.11 – LCC 25 000
= LCC 9 901.11.

The company thus borrows at the market rate of 11.2%, but this rate is reduced by the amount paid by the bank to the company less the premium paid to the bank:

Cost to company = (C × ir × t) – (SA – P)
= (LCC 20 000 000 × 0.112 × 91 / 365) – (LCC 9 901.11)
= LCC 558 465.75 – LCC 9 901.11
= LCC 548 564.64

Total interest rate paid = (LCC 548 564.64 / LCC 20 000 000) × (365 / 91)
= 0.0274282 × 4.010989
= 0.110001
= 11.00% pa.

This of course ignores the fact that the premium is paid upfront.

9.3.3 Floors

It is useful to elucidate floors with the use of a specific example: *investing company buys a T3-month – T6-month floor* (see Figure 16).

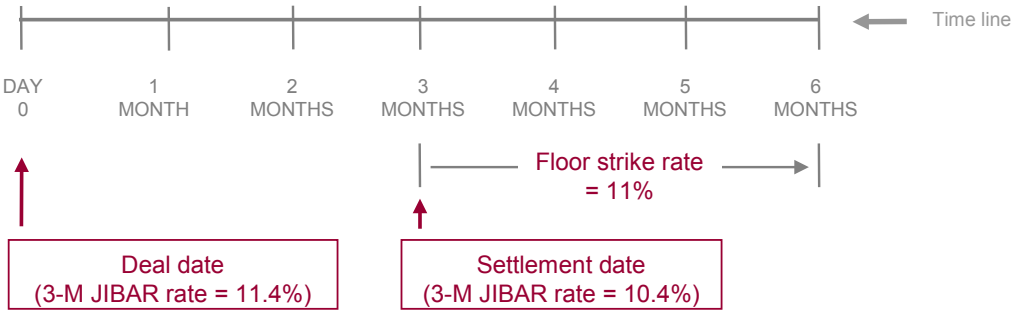

Figure 16: example of T3-month – T6-month floor

An investor expects to receive LCC 20 million in 3 months' time, and these funds will be free for 3 months before it is required for a project. The investor *expects rates to fall* and would like to lock in a 3-month rate now for the 3-month period (assume 91 days) in three months' time. He approaches a dealing bank and receives a quote for a T3m–T6m floor at 11.0% on a day when the 3-month market (JIBAR) rate is 11.4%. He verifies this rate with other dealing banks, and decides to deal. The premium payable is LCC 19 000.

Three months later (on the settlement date) the JIBAR 3-month rate is 10.4% pa. The investor was correct in his view and the bank not, and the bank coughs up the following (fsr = floor strike rate):

$$\begin{aligned} SA &= NA \times [(fsr - rr) \times t] \\ &= LCC\ 20\ 000\ 000 \times [(0.11 - 0.104) \times 91 / 365] \\ &= LCC\ 20\ 000\ 000 \times (0.006 \times 91 / 365) \\ &= LCC\ 20\ 000\ 000 \times 0.00149589 \\ &= LCC\ 29\ 917.81. \end{aligned}$$

The financial benefit to the company is:

$$\begin{aligned} &\text{Financial benefit} \\ &\quad = SA - P \\ &\quad = LCC\ 29\ 917.81 - LCC\ 19\ 000 \\ &\quad = LCC\ 10\ 917.81. \end{aligned}$$

The company thus *invests* at the 3-month *cash (spot) market rate* of 10.4% pa on the settlement date, and its earnings are boosted by the settlement amount less the premium paid to the bank:

$$\begin{aligned} &\text{Earning on investment} \\ &\quad = (C \times ir \times t) + (SA - P) \\ &\quad = [LCC\ 20\ 000\ 000 \times (0.104 \times 91 / 365)] + LCC\ 10\ 917.81 \\ &\quad = (LCC\ 20\ 000\ 000 \times 0.025929) = LCC\ 10\ 917.81 \\ &\quad = LCC\ 518\ 575.34 + LCC\ 10\ 917.81 \\ &\quad = LCC\ 529\ 493.15. \end{aligned}$$

Thus, the *actual rate* (ignoring the fact that the premium is paid upfront) earned by the company is:

Total interest rate earned
= (LCC 529 493.15 / LCC 20 000 000) × (365 / 91)
= 0.0264747 × 4.010989
= 0.1061897
= 10.62% pa.

It will be evident that if the spot market rate is say 11.5%, the treasurer of the investing company *will let the floor contract lapse* (i.e. *not exercise*). He will invest at 11.5% for the 3-month period, but this return is eroded by the premium paid for the floor. The following are the relevant numbers:

Earnings on investment
= (C × ir × t) – P
= (LCC 20 000 000 × 0.115 × 91 / 365) – LCC 19 000
= LCC 573 424.66 – LCC 19 000
= LCC 554 424.66.

It will be apparent that the interest rate actually earned by the company (ignoring the fact that the premium is paid upfront) is:

Total interest rate earned
= (LCC 554 424.66 / LCC 20 000 000) × (365 / 91)
= 0.0277212 × 4.010989
= 0.1118943
= 11.12% pa.

Thus, the investor would have been *worse off* if he had exercised the floor.

5.9.4 Options on specific bonds

An option on a specific bond, also called a bond option, may be defined as *an option to buy (call) or sell (put) a specific bond on or before an expiry date at a pre-specified price or rate.* "Price or rate" is mentioned because some markets deal on price and some on rate. Bond option markets are OTC or exchange-driven markets.

In the OTC options markets, the contracts are generally standardised (in most respects). Options are written on the most marketable short- and long-term bonds, which are the high-capitalisation bonds.

The OTC bond options written and traded are of the standardised and American variety. European options are also written from time to time, and there are also non-standardised options. The latter, which include "overnighters" (i.e. contracts written to expire the following day) are usually written to suit particular hedging strategies. They differ from the standardised contracts in terms of expiration date and strike rate level.

The main characteristics of standardised bond options are shown in Table 9.

Size of contract	LCC 1 million (nominal value), but the standard trading amount is LCC 10 million or multiples of this amount
Underlying instruments	Various government and public enterprise bonds
Market price/rate	Yield to maturity
Strike rate intervals	0.25%, for example 8.00%, 8.25%, 8.50%, 8.75%
Expiry dates	12 noon on the first Thursday of February, May, August and November
Commission	As there are no fixed commission rates, the commission is included in the premium paid by the purchaser
Form of settlement	Cheque for the premium negotiated on the day of settlement

Table 9: Characteristics of standardised bond options

Listed bond options are options on specific bonds that are listed on an exchange. Many exchanges have such options.

5.9.5 Options on bond indices

A bond index option may be defined as an option to buy (call) or sell (put) a specific bond index on or before an expiry date at a pre-specified price (not rate; rate applies to options on specific bonds). Local Country, for example, has the following bond indices[56]:

- *All Bond Index* (ALBI), consisting of the most liquid sovereign (i.e. central government) and non-sovereign (e.g. local government, public utilities and corporate) bonds.
- *Government Bond Index* (GOVI), containing those government bonds of the ALBI in which the primary dealers make a market, i.e. the most liquid bonds.
- *Other Bond Index* (OTHI), being the non-govenment bonds in the ALBI basket.

The indices enable investors to measure the performance of bonds of various terms. Bond options are written on these three indices.

5.9.6 Bond warrants (call options)

There are two types of bond warrants:

- Bond warrants (retail options).
- Bond warrants (call options).

The term "bond warrant" internationally generally refers to *call* options on specific bonds but with a difference: when a bond warrant (call option) is exercised, this leads to the issuer issuing *new bonds*. In the case of the ordinary bond options, the issuer is not involved – the writer of a call that is exercised sells existing bonds to the holder of the option.

The term to expiry of bond warrants (call options), unlike normal options, is long, sometimes running for many tears. The underlying bond also has a long term to maturity, usually 10 years or longer.

5.9.7 Bond warrants (retail options)

In some countries, however, the term "bond warrant" refers to ordinary options on specific bonds, but they are *retail options*, i.e. the denominations are small. Calls and puts are written and traded and a call does *not lead to the issue of new bonds*.

The issuer of bond warrants is an entity, usually a bank, which is not associated with the issuer of the underlying bond (which in the main is government bonds). The issuer of the warrant is the writer, and the holder therefore has the right to exercise it against the issuer. As such the warrant holder assumes counterparty risk, i.e. the credit risk associated with the issuer.

Bond warrants enable investors / speculators to profit from expected movements in interest rates on specific bonds. Call warrants are bought in order to profit from an expected increase in the bond price (decrease in ytm), and bond put warrants are bought to profit from an expected decrease in the bond price (increase in the ytm).

There are two types of bond warrants: American or European. They are usually listed on the exchange and are traded and settled with members of the exchange (therefore settlement is guaranteed by the exchange). The issuers of warrants make a market in them by quoting bid and offer prices simultaneously at all times. The buyer pays the premium quoted by the market-maker. Bond warrants are cash settled.

The advantages of warrants and the risks associated with warrants are covered under equity warrants below, as this is the largest warrants market in most countries.

5.9.8 Callable and puttable bonds (bonds with embedded options)

Bonds with embedded options are bonds that are issued with *provisions* that allow the *issuer to repurchase* (callable bond) the bond, or the *holder to sell back to the issuer* (puttable bond) the bond at a pre-specified price/rate at certain dates in the future.

The *callable bond* means that the buyer of the bond has sold to the issuer a call option to repurchase the bond. The strike price/rate (also called the *call price*) is the pre-determined price/rate that the issuer is obliged to pay to the bondholder.

It is usual that callable bonds are not callable for some years after issue. For example, a 15-year bond may not be callable for 10 years, and a price is set for each year after 10 years. A portion of the bond or the full amount may be callable. The fact that the buyer has "sold" to the issuer a call option means that these bonds are issued at a lower price (higher rate) than equivalent term and rated "ordinary" bonds.

Puttable bonds, i.e. bonds with embedded put options, are also issued in some markets. As noted, such bonds have provisions that allow the holder to sell the bond back to the issuer at pre-specified prices/ rates on pre-determined dates. This means that the holder of the bond has bought a put option from the issuer. These bonds are issued and trade at lower yields (higher price) than equivalent term and rated bonds without such options attached.

5.9.9 Convertible bonds

Convertible bonds are bonds that are *convertible into shares* (ordinary or preference) at the *option of the holder* on pre-specified terms (e.g. number of shares per nominal value).

5.10 Options on equity / share market instruments

5.10.1 Introduction

We repeat our illustration on options introduced earlier for the sake of orientation (see Figure 17).

Options on equities may be divided into the following categories:

- Options on specific equities.
- Options on equity / share indices.
- Equity / share warrants (call options).
- Equity / share warrants (retail options).
- Redeemable preference shares.

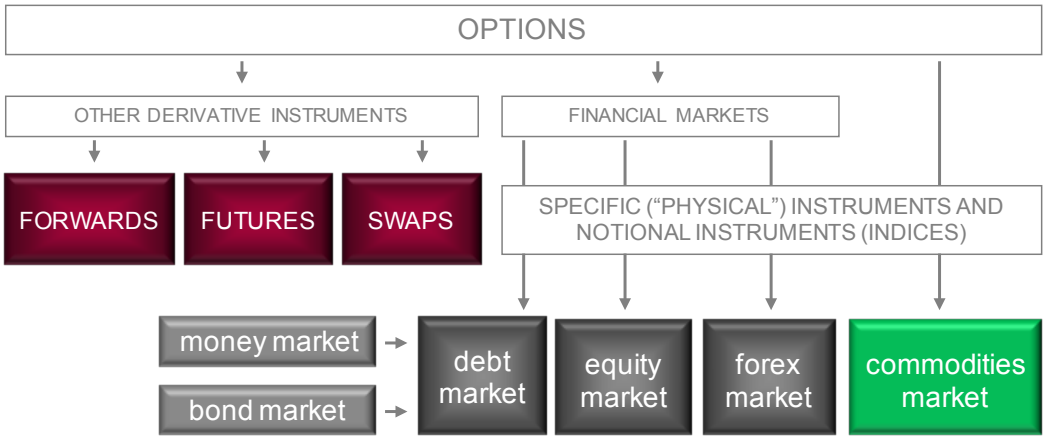

Figure 17: options

Examples of the options in the first two categories are shown in Table 11 for the US market. The many different exchanges involved in these markets will be noted. It is obvious that these markets are exchange-traded, but it should be pointed out that there is also an OTC market in shares and these and other indices.

Type	Exchange	Share / index
Options on shares (stocks in US)	CBOE AM PB PC NY	Many specific shares (stocks) Many specific shares (stocks) Many specific shares (stocks) Many specific shares (stocks) Many specific shares (stocks)
Options on share (stock in US) indices	CBOE CBOE CBOE AM PB PB PB	Dow Jones Industrial Average NASDAQ 100 S&P 100 index Major market index Gold Oil service index Utility index
CBE = Chicago Board of Trade. CME = Chicago Mercantile Exchange. LIFFE = London International Financial Futures Exchange. CBOE = Chicago Board of Option Exchange. AM = American Exchange. PB = Philadelphia Exchange. PC = Pacific Stock Exchange. NY = New York Stock Exchange.		

Table 11: Examples of US market options on equities

5.10.2 Options on specific equities

There are many exchanges in the US and the UK (and other markets including the JSE) that list and trade options on specific equities. Such options are usually written on the shares that have a large market capitalisation, and are well traded (i.e. liquid). An example is required (see Table 12).[57]

Strike price	Calls			Puts		
	Dec	Mar	Jun	Dec	Mar	Jun
360	27.0	33.0	38.5	0.5	7.5	12.5
390	6.5	14.5	**22.0**	10.0	22.0	27.0

Table 12: Lloyds TSB equity / share options (quoted on liffe) (current price 384 pence)

In this example there are two strike prices, i.e. 360 pence and 390 pence at a time when the share in trading at 384 pence. The limited number of strike rates and contract maturity dates ensure that there is liquidity in the option contracts.

There are two sets of prices quoted, i.e. one for call options and one for put options. For example, the June call price at a strike price of 390 is 22.0 pence. This means that a buyer of this call option will pay 22 pence per share. The minimum contract size is 100 shares; thus the option contract will cost the buyer GBP 220 (i.e. the premium). The buyer of the call has the right but not the obligation to buy 100 Lloyds shares at a price of 390 pence and the cost of the option is GBP 220. Alternatively, a June put option at a strike price of 390 will cost GBP 270, and this will bestow upon the buyer the right to sell 100 Lloyds shares at a price of 390 pence at any stage up to the expiry date of the option in June.

The markets in options on individual shares are large, and they are usually exchange-traded. There are also OTC markets in options on individual shares.

There is also an option that is a hybrid of an exchange listed option and an OTC option in that it is listed but has the flexibility of an OTC option: the so-called *Can-Do Option*. It is designed to provide fund managers with a means to tailor derivatives to their particular exposures.

The following features distinguish it from other options on equities:

- Minimum contract size = large (usually the local equivalent of USD 1 million indicating that it is aimed at the professional investor).
- Contract size = any amount over local equivalent of USD 1 million.
- Underlying instruments = basket of shares can be specified by the investor.
- Expiry date = specified by the investor.
- Settlement = cash or physical at the option of the investor.

5.10.3 Options on equity / share indices

The options on indices markets of the world are also large and active. Examples of indices are the FTSE 100 in the UK, the DJIA and the S&P 500 in the US, the ALSI and the INDI in South Africa. They are mostly exchange-traded, but an OTC market also exists.

An option on a share index allows the holder to take a position in the index (short or long) for the price of the premium quoted. This means that to buyer of a share index is buying the right to "invest" in a diversified portfolio (of the shares that make up the index) at a pre-specified price.

The size of index options is established by a multiplier applied to an index, i.e. the size of a share index option is equal to the index value (specifically the strike index value / price – SIV) times the multiplier. For example, the size of an option on the S&P 500 is = SIV × USD 500. In the case of the DJIAA it is SIV × USD 100. If for example the SIV on the S&P 500 = 1635, the size / exposure of the option = 1635 × USD 500 = USD 817 500. These options are *settled in cash*, obviously because the index cannot be delivered.

An example may be constructive here:[58] An investor has a portfolio that he set up to replicate the S&P 500 share index. He is concerned that monetary policy is about to be tightened and that share prices are about to fall sharply, but he does not want to sell because it is expensive to sell and to reconstruct this portfolio again after the fall (because of brokerage, taxes, etc). The value of his portfolio is USD 2.8 million and the S&P 500 SIV of a 3-month put option = 1400. The size of each option is thus 1400 × USD 500 = USD 700 000. The investor will buy four 3-month put options on the S&P index. Thus the investor is hedging his USD 2.8 million portfolio with four put options = USD 2 800 000 (4 × USD 500 × 1400).

We assume that the investor is right in his view and the index over three months falls to 1120 (i.e. by 280 points or 20%). The value of the investor's portfolio will be USD 2.24 million (remember he replicated the S&P 500 index with "physical" shares), i.e. he incurs a loss of USD 560 000[59]. However, the investor exercises the four put options on expiry date, and makes a profit of:

(1400 – 1120) × USD 500 × 4 = USD 560 000,

which = the loss on his portfolio.

5.10.4 Equity / share warrants (call options)

As in the case of bond warrants, internationally equity / share warrants bestow the right (option) on the holder of the warrant to take up *new shares* of the relevant company. These call options are usually long term in duration.

5.10.5 Equity / share warrants (retail options)[60]

In some countries a version of equity / share warrants (as in the case of bond warrants) exist: they are ordinary options (call and put options), but are small in size, i.e. retail. Exercising of a warrant does not lead to the issue of new shares of the relevant company. Warrants are also written on equity / share indices.

The retail warrants market has grown rapidly in recent years. Warrants comprise call and put options on specific shares and on certain indices. They are of the American and European varieties and are usually listed on the exchange. As such they are traded and settled via a stockbroking broker-dealer firm. The issuers make a market in their equity warrants, i.e. quote bid (holder sells to the issuer) and offer (holder buys from the issuer) prices simultaneously, for example, bid: 12 cents / offer: 13 cents (these prices are called premiums).

The advantages of warrants are many. One of the issuers and market-makers lists eight as follows[61]:

1. Warrants enable investors to trade on the exchange with the same ease as trading ordinary shares.
2. Warrants offer a low cost entry into blue chip shares.
3. There is potential to leverage or gear up your investment.
4. Your risk is limited to the initial premium (price of the warrant) paid.
5. Warrants have the transparency of a listed instrument.
6. Small investors can short the market or hedge their portfolios through the use of put warrants and so profit from falls in the market.
7. The warrants market is extremely liquid, as the issuer is required to provide both bids and offers.
8. Warrants are an extremely cheap instrument to trade.

The risks associated with warrants are price risk and credit risk. However, as shown above, price risk is limited to the premium which is a fraction of the value of the relevant share; i.e. there is limited downside risk and marked upside profit opportunity. While settlement is guaranteed by the exchange, the holder takes on credit risk because the counterparty to the deal is the issuer. As seen, these are the larger banks; as such credit risk is deemed to be small.

As noted, warrants are written on specific shares, usually the high market capitalisation shares, and on certain indices. In addition to the "ordinary" equity warrants, there are a number of variations on the theme, such as reset warrants and knockout warrants.

5.10.6 Redeemable preference shares

Preference shares (also called "preferred stock") in many countries are like perpetual bonds in that they never mature: perpetual preference shares. In other countries they are required to be redeemable or redeemable at the *option* of the issuer.

5.11 Options on foreign exchange

5.11.1 Introduction

We repeat our illustration on options introduced earlier for the sake of orientation (see Figure 18).

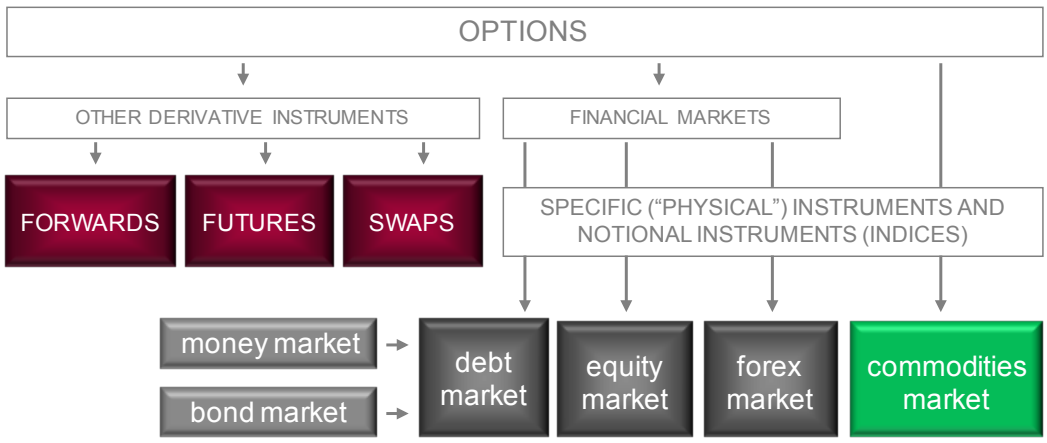

Figure 18: options

As in the case of bonds and shares, the options market in foreign currency can be divided into the wholesale and retail markets as follows:

- Options on foreign exchange (wholesale).
- Options on foreign exchange (retail: warrants).

5.11.2 Options on foreign exchange (wholesale)

Options on foreign exchange (also called *currency options*) are traded the world over, and the most tradable contracts are those written on USD / EUR (example: EUR 62 500 on the PHLX), USD / JPY (example: JPY 12 500 000 on the PHLX), USD / GBP (example GBP 31 250 on the PHLX), USD / CAD (example: CAD 50 000 on the PHLX), USD / AUD (example: AUD 50 000 on the PHLX). In the US, the Philadelphia Options Exchange (PHLX) is particularly active in currency options.

The underlying asset in a currency option is an exchange rate. A call option on the GBP for example will give the buyer the right to buy GBP for a given price in dollars (i.e. the strike price).

Strike price	Calls			Puts		
	June	July	August	June	July	August
1.63	**1.5**	2.4	2.9	1.1	1.55	2.23
1.64	1.3	1.84	2.35	1.5	2.01	2.62
1.65	0.94	1.43	1.89	1.05	2.55	3.21

Table 13: Philadelphia options exchange GBP / USD options GBP 31 250 (cents per GBP)
(spot price: GBP / USD 1.6383)

An example is always useful (see Table 13). The GBP / USD spot price is GBP / USD 1.6383. The face value of currency option contracts is fixed at an amount of currency; in this example it is GBP 31 250). A US investor purchases a June GBP *call* option at an exercise / strike price of 1.63 (this of course means GBP / USD 1.63). The face value of the contract is GBP 31 250.

At the end of the life of the option the GBP increases in value relative to the USD. We assume GBP / USD 1.76. The investor exercises the option and receives GBP 31 250 for which he pays USD 50 937.50 (1.63 × GBP 31 250). The investor sells the GBP in the spot forex market at the spot exchange rate of GBP / USD 1.76, and receives USD 55 000 (1.76 × GBP 31 250). The profit made is USD 4 062.50 (USD 55 000 – USD 50 937.50) less the premium paid for the option.

The *premium* is quoted in US cents per GBP. In the above example the premium is 1.5 US cents per GBP, i.e. the premium amount is 31 250 × 1.5 / 100 = USD 468.75. Total net profit is USD 3 593.75 (USD 4 062.50 – USD 468.75).

5.11.3 Options on foreign exchange (retail: warrants)

In addition to the wholesale market, there exists a market in retail options on foreign currencies. In some copuntries these are called *currency reference warrants* (CRWs).[62] CRWs are of the European variety, are available as call and put warrants, are usually listed on the exchange, and are cash settled.

CRWs enable investors to hedge themselves against unexpected movements in the LCC. Call warrants enable investors to buy a foreign currency (i.e. to sell the LCC) when they believe the LCC will weaken (read: pay more LCC for one unit of the foreign currency). On the other hand, put warrants enable investors to sell a foreign currency (i.e. to buy the LCC) when they believe the LCC will strengthen (read: less LCC for one unit of the foreign currency)

5.12 Options on commodities

The commodities options markets are also large markets internationally, but they fade into the background when compared with the options on financial instruments markets. Options are written on all the larger commodities, such as gold, oil, wheat, maize, soybean, and certain commodity indices such as the AMEX oil index. The commodity options markets are both formalised and OTC.

In addition to the wholesale options on commodities market, there exists a retail market: warrants on commodities.[63] These are called *commodity reference warrant* (CoRWs) in some countries. The underlying assets of CoRWs are commodities such as gold, platinum, and oil, expressed in LCC. They are available in puts and calls.

5.13 Option strategies

5.13.1 Introduction

There are no fundamental dissimilarities between operations in the futures and options markets, i.e. dealings in the options market can be divided into the four types:

- Speculative.
- Hedging.
- Arbitrage.
- Investment.

However, we know that a hedger, speculator or investor has the choice between futures and options, and the essential difference between them is that in the case of the options the buyer has limited downside risk. We also know that there are a number of payoff situations for buyers are sellers of options. In addition, a virtually unlimited variety of payoff patterns may be attained by the *combination* of calls and puts with various exercise prices. Here we consider only two of the combinations of options, the straddle and the strangle.[64]

5.13.2 Straddle

Underlying price of share at expiry	Profit / loss on call option	Profit / loss on put option	Net profit / loss on straddle
440	-10	+31	+21
445	-10	+26	+16
450	-10	+21	+11
455	-10	+16	+6
460	-10	+11	+1
465	-10	+6	-4
470	-10	+1	-9
475	-10	-4	-14
480	**-10**	**-9**	**-19**
485	-5	-9	-14
490	0	-9	-9
495	+5	-9	-4
500	+10	-9	+1
505	+15	-9	+6
510	+20	-9	+11
515	+25	-9	+16
520	+30	-9	+21

Table 14: Profit / loss profile of a long straddle

	$SP_t < X$	$SP_t \geq X$
Payoff of call	0	$SP_t - X$
+ Payoff of put	$X - SP_t$	0
= Total	$X - SP_t$	$SP_t - X$

Table 15: Value of straddle at expiry

The straddle is generally put into place when an investor *believes that the price of the underlying is about to "run" but she is uncertain of the direction*. The straddle involves the purchasing of *a call and a put at the same strike price and expiration date*.

The share price of Company ABC is trading at 480 pence currently. The price of a call at a strike of 480 pence is 10 pence and the price of a put at the same strike is 9 pence. The position is held to maturity (six months from purchase). Table 14 and Figure 19 set out the profit and loss profile.

The solid line in the lowest part of the chart shows the payoff condition of the straddle. At $X = SP_t$ the payoff is equal to zero. It is only at this point that the payoff is zero; at all other points the straddle has a positive payoff. One may then ask why these combinations are not more popular. The answer is that if prices are not volatile the holder may lose heavily because she is paying a *much higher premium* than is usually the case.

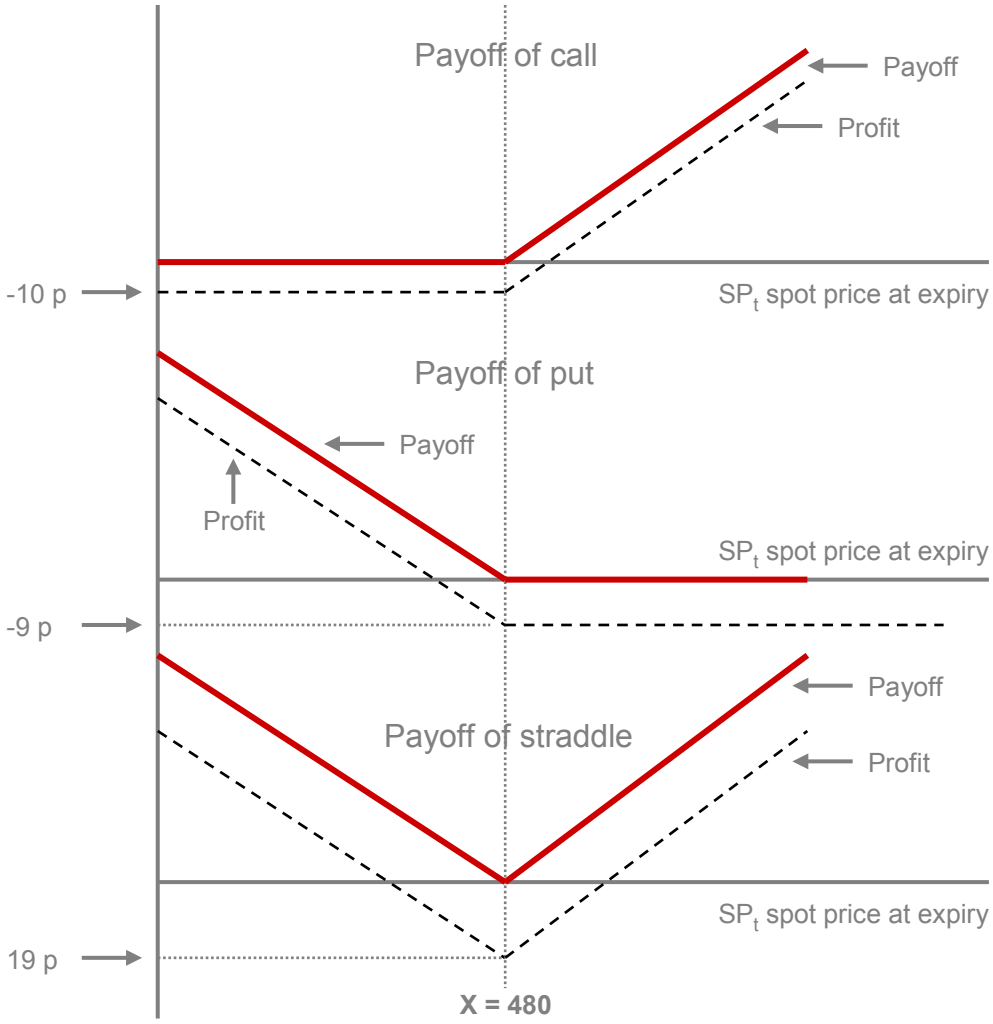

Figure 19: profit / loss profile of a long straddle

The dotted line in the chart represents the profit of the straddle. It is below the solid line by the cost of the straddle, i.e. the premium, in this case 19 pence. This is the maximum that can be lost.

5.13.3 Strangle

A strangle is the *same as the straddle except that the exercise prices differ*. An example is shown in Table 16.[65]

The share price of Company ABC is trading at 480 pence. The price of a call option at strike 460 is 25 pence, and the price of the put at strike 480 is 9 pence. The table shows the payoff profile. It will be clear that there is a range where maximum losses are made and this is between the two strike prices. The loss is capped at 14 pence. Beyond this range the losses are reduced or profits rise and they do so in a symmetrical fashion.

Underlying price of share at expiry	Profit / loss on call option	Profit / loss on put option	Net profit / loss on straddle
440	-25	+31	+6
445	-25	+26	+1
450	-25	+21	-4
455	-25	+16	-9
460 (call strike)	**-25 (call premium)**	+11	**-14**
465	-20	+6	**-14**
470	-15	+1	**-14**
475	-10	-4	**-14**
480 (put strike)	-5	**-9 (put premium)**	**-14**
485	0	-9	-9
490	+5	-9	-4
495	+10	-9	+1
500	+15	-9	+6
505	+20	-9	+11
510	+25	-9	+16
515	+30	-9	+21
520	+35	-9	+26

Table 16: Profit / loss profile of a long strangle

5.13.4 Delta hedging

In normal hedging strategies (for example, holding of an asset and buying a put with the asset as the underlying when it is expected that its price will decline), some hidden risks lurk, requiring an appreciation of the "Greeks": delta, theta, gamma, vega and rho. We covered them briefly earlier. Here we discuss the most prominent one, delta, and specifically delta hedging, in a little more detail.

It will be recalled that *delta* is the rate of change of the option price with respect to the price of the underlying asset. If a call option has a delta of +1 it means that when the value of the underlying increases, the value of the option changes by the same amount. If the delta of a call option is +0.5, it means that when the price of the underlying increases by a number, the price of the option changes by 50% of that number. (It will be clear that the delta of a put option is negative.) When the delta of an option is removed from +1 or -1 (i.e. closer to 0), it constitutes risk in a hedge. The delta can also change over time due to changes in the underlying price, volatility or a shortening of the time to expiration (referred to as *delta-variable*).

A *delta-neutral* position is obtained when an options / underlying instrument position is constructed so that it is insensitive to price movements in the underlying instrument. Thus, if an investor has a long position in shares, she is able to hedge the position against losses by buying puts (long put position) or selling calls (short call position) to the extent of the *inverse of the delta*. If the delta of a put option is 0.75, the *hedge ratio* is 1 / 0.75 = 1.33. This means that 1.33 put options are required to offset one unit of the long position in shares. With this in place the investor has a *delta-neutral hedge.*

An example: if an investors holds 30 000 ABC shares, she will need to buy put options (with a delta of 0.75) to the extent of 30 000 / 0.75 = 40 000 (assuming a put option on 1 share could be bought). If the put option contract size is 1 000 shares, then 40 contracts are required [30 000 / (0.75 × 1 000)] to achieve a *delta-neutral hedge.*

As noted above, the delta values of options contracts do change over time; therefore the position needs to be rebalanced every so often to maintain a hedge ratio of h = -1. This is called *dynamic hedging*.

5.14 Exotic options[66]

Securities broker-dealers and investment banks have over the years developed many so-called exotic options. Many of them cross the various markets. The following may be mentioned as examples:

As you like it options (AYLIO)

The AYLIO is an option that allows the holder to convert from one type of option to another at a certain pre-specified point prior to expiration. This is usually from a call to a put or vice versa. This option type is also called "call or put option" or "chooser option".

Average rate options (ARO)

The ARO is an option on which settlement is based on the difference between strike price and the average of the share or index on certain given dates. The "average" attribute of the ARO renders this option less volatile and thus cheaper than a conventional "spot price option". The ARO is also called an "Asian Option".

Barrier options (BAO)

There are many types of barrier options. Their payoff is dependent on the price of the underlying asset and on whether the asset reaches a pre-determined barrier at any time in the life of the option. There are, for example, knock-in options and knock-out options. The former is activated when the price of the underlying asset reaches a pre-determined level. The latter option is "killed" if the price of the underlying reaches a pre-determined level.

Compound options (CO)

A CO is an option on an option. The buyer has the right to buy a specific option at a preset date at a preset price.

Lookback options (LO)

A LO is an option where the payout is determined by using the highest intrinsic value of the underlying security or index over its life. For a lookback call the highest price is used, whereas the lowest price is used in a lookback put.

Quantro options (QO)

A QO is a currency option in terms of which the foreign exchange risks in an underlying security have been eliminated.

Package options (PO)

A PO is a portfolio consisting of standard European calls, standard European puts, forward contracts, cash and the underlying asset itself. An example is a range forward contract.

Forward start options (FSO)

FSOs are options that start their life at some stage in the future. They are used in employee incentive schemes.

Binary options (BIO)

BIOs are options with discontinuous payoffs. An example is a cash-or-nothing call. This pays off nothing if the share price ends up below the strike price at some time in the future and pays a fixed amount if it ends up above the strike price.

Shout options (SO)

SOs are European options where the holder can "shout" to the writer at one time during its life. At the end of the life of the option the holder receives either the usual payoff from a European option or the intrinsic value at the time of the shout whichever is greater.

Other options

There are also other options such as options to exchange one asset for another (*exchange options*), options involving several assets (*rainbow options*), basket options, etc.

5.15 Summary

An option is the right to buy or sell an asset on or during the period up to the option expiry date which is in the future (in exchange for a premium). The writer has an obligation to receive or deliver the asset on or before expiry date. Options are written on most financial market instruments and many commodities. Seen simply an option is worth the intrinsic value and the time value of the option. The most used pricing formula includes a number of variables.

- Spot (current) price of underlying asset (assume share) (SP).
- Exercise (strike) price (EP).
- Time to expiration.
- Risk free rate (i.e. treasury bill rate).
- Dividends expected on the underlying asset during the life of the option.
- Volatility of the underlying asset (share) price.

5.16 Bibliography

Applied Derivatives Trading Magazine, 1998. November.

Bodie, Z, Kane, A, Marcus, AJ, 1999. **Investments**. Boston: McGraw-Hill/Irwin.

Falkena, HB, et al., 1991. **The options market.** Halfway House: Southern Book Publishers (Pty) Limited.

Faure, AP, 2005. **The financial system**. Cape Town: QUOIN Institute (Pty) Limited.

Hull, JC, 2000. **Options, futures, & other derivatives** (4e). London Prentice-Hall International, Inc.

McInish, TH, 2000. **Capital markets: A global perspective**. Massachusetts, USA: Blackwell Publishers Inc.

Mishkin, FS and Eakins, SG, 2000. **Financial markets and institutions** (3e). Reading, Massachusetts: Addison-Wesley.

Rose, PS, 2000. **Money and capital markets** (international edition). New York: McGraw-Hill Higher Education.

SAFEX (Financial Derivatives and Agricultural Products Divisions of the JSE Securities Exchange South Africa), 2003. [Online]. Available: www.safex.co.za. [Accessed October].

Saunders, A, 2001. **Financial markets and institutions** (international edition) New York: McGraw-Hill Higher Education.

Santomero, AM and Babbel, DF, 2001. **Financial markets, instruments and institutions** (2e). Boston:. McGraw-Hill/Irwin.

Spangenberg, P, 1999. The mechanics of option-styled interest rate derivatives – caps and floors. **The Southern African Treasurer**. 11. December.

Standard Bank., 2004. [Online]. Available: www.warrants.co.za. [Accessed June].

Steiner, R, 1998. **Mastering financial calculations.** London: Financial Times Management.