Chapter 6

The valuation of derivative contracts

Periodically, banks have to report the market value of derivative contracts, for instance, to their clients or to the regulators or for internal reports. In the financial markets, a distinction is made between linear and non-linear derivatives. Linear derivatives are derivatives for which the future cash flows will certainly take place, assuming that the counterparty will not default. This is opposite to options, where it is not certain whether one or more future cash flow will take place. For the valuation of linear derivatives, treasury systems use the discounted cash flow method. This method calculates the present value of all future cash flows of a financial instrument and takes the net present value of these cash flows as the current value of this instrument. In this chapter we will discuss an easier alternative for this method. For the valuation of options, a more complex model is necessary. An example of such a model is the Black-Scholes model which we will discuss conceptually in this chapter.

6.1 The price determining parameters and the market value of derivatives

The price of a derivative contract is agreed at the moment on which it is transacted and is based on the prevailing market conditions for the price determining parameters on that particular moment. The table below shows the price determining parameters for FX forwards, for interest rate swaps and for options (excluding the applied credit spread).

<table>
<tr><th colspan="3">Price determining parameters</th></tr>
<tr><th>FX forward</th><th>Interest Rate Swap</th><th>Options</th></tr>
<tr><td rowspan="4">FX forward rate</td><td rowspan="2">Interest rate on the capital market for the term of the swap</td><td>Difference between the forward price of the underlying value and the strike price</td></tr>
<tr><td></td></tr>
<tr><td rowspan="2">(Remaining) term</td><td>Volatility</td></tr>
<tr><td>(Remaining) term</td></tr>
</table>

The price of an FX forward contract, for instance, is determined by the FX spot rate on the transaction date and the interest rate differential at that time which together form the FX forward rate. The price of an interest rate swap, for instance, is determined by the conditions on the capital market on the moment that the transaction is concluded et cetera.

Immediately after a derivative transaction has been concluded, the market conditions would, most probably, already be different. This is because the prices and rates on the financial markets change constantly. These movements can be either favourable or unfavourable for the contract parties. Put in other words: the derivative contracts become to have a market value. If the market moves in a favourable direction, then a contract becomes to have a positive market value whereas if the market moves in an unfavourable direction, then a contract becomes to have a negative market value.

On the moment that an FX forward contract or an interest rate swap is concluded, the market value is zero. This is because both market parties enter into an obligation towards each other and these mutual obligations have exactly the same value. If the current FX forward rate is, for instance, 1.1300 and two market parties agree to exchange EUR 1,0000,000 euro against USD 1,300,000 on a future settlement date then one party has the obligation to transfer 1,000,000 euro on that date whereas the other party has the obligation to transfer USD 1,300,000 on that date. However, on the transaction moment, USD 1,300,000 has a value of exactly EUR 1,000,000 which means that the value of the both obligations is the same and that, as a result, the 'net value' (the market value) of the FX forward is zero.

6.1.1 Changes in the market value of FX forwards

In this paragraph we will explain how a change in the FX forward rate will change the market value of an FX forward.

Example

On 1 May a Dutch company has concluded an FX forward transaction in which it buys 500,000 USD at an FX forward rate of 1.1300 with settlement date 1 August. This contract rate was based on the market conditions on a May and the counter value in euro is 500,000 / 1.1300 = EUR 442,478.

If, on a specific moment during the term, for instance 1 June, the FX forward rate for 1 August would be 1.1500 this would mean that the company would have to pay less euro if it would not had concluded the FX forward on 1 June but instead would transact an FX forward on 1 June. The counter value in euro would now be 500,000 / 1.1500 = EUR 434,783 which is EUR 7,695 less.

The FX forward contract in the example turns out to be transacted under less favourable market conditions than the conditions on 1 June. The difference between the euro contract amount in a transacted derivative contract (in the remainder of this chapter we will refer to this contract as the original contract) and the euro contract amount in a virtual contract which could be concluded on a specific moment during the contract term of the original contract gives the (future) market value of the derivative contract. The market value of the FX forward contract in the example is, therefore, EUR 7,695 negative.

In our example, the Dutch company had bought USD in the FX forward contract, which means that the company has sold euro. During the term, the EUR/USD FX forward rate went up and, as a result, the contract became to have a negative value. If the EUR/USD rate would have gone down, on the other hand, the FX forward contract would become to have a positive value. The relationship between movements in the price determining parameter (the FX forward rate) and the value of an FX forward contract are shown in the below table.

	Buy EUR / Sell foreign currency	**Sell EUR / Buy foreign currency**
FX forward rate becomes higher than the contract rate	Positive market value	Negative market value
FX forward rate becomes lower than the contract rate	Negative market value	Positive market value

6.1.2 Changes in the market value of interest rate swaps

In this paragraph we will explain how a change in interest rates changes the market value of an interest rate swap.

Example

On 30 May a company has concluded an interest rate swap transaction in which it pays a fixed rate of 3% and receives 6-month EURIBOR. The term of the interest rate swap is five years and the contract amount is EUR 10,000,000.

If, on a specific moment during the term, for instance after one year, the interest rates would have decreases, for instance to 2%, then this would mean that the company would have to pay a lower interest rate if it would not had already concluded the interest rate swap one year ago but would an interest rate swap one year later. If the company would have concluded the interest rate swap after one year, then it would only have to pay 2% over 10,000,000 = EUR 200,000 instead of EUR 300,000 for the remaining four years. This means that the company is paying EUR 800,000 more in the original transaction during the remaining term of the swap than it would have to pay if it would have concluded the transaction after one year.

The interest rate swap contract in the example turns out to be transacted under less favourable market conditions than the conditions after one year. The difference between the obligations to pay the fixed coupon in the original contract and the obligations to pay the fixed coupon in a virtual contract which could be concluded on a specific moment during the contract term of the original contract gives the market value of the derivative contract. The (future) market value of the interest rate swap contract in the example is, therefore, EUR 800,000 negative.

In our example, the company was paying the fixed rate. During the term, the interest rates decreased and, as a result, the contract became to have a negative value. If the interest rates would have gone up, on the other hand, the interest swap contract would become to have a positive value. The relationship between movements in the interest rates and the value of an interest rate swap contract is shown in the below table.

	Pay the fixed rate	**Receive the fixed rate**
Interest rate becomes higher than the contract rate	Positive market value	Negative market value
Interest rate becomes lower than the contract rate	Negative market value	Positive market value

6.1.3. The Option premium

The value of an option is made up of two parts, the intrinsic value and the time value.

Intrinsic value

The intrinsic value of an option is the difference between the (forward) market price of the underlying value and the exercise price viewed from the perspective of the buyer, if positive. If the price of the underlying is the same or lower than the exercise price, the intrinsic value of a call option is zero. If the price of the underlying is higher than the exercise price, the call option has a positive intrinsic value. If the price of the underlying value rises further above the exercise price, the intrinsic value increases proportionally. In other words, for every unit price increase of the underlying value, the intrinsic value of a call option increases by one unit. The intrinsic value can also be found by answering the following question: ‘What would be the value of the option contract if the remaining term of the option contract was zero?’

In the table below, the intrinsic value of a EUR call / USD put option with a strike price of EUR / USD 1.3400 is shown.

Spot rate	Intrinsic Value
1.3200	0
1.3300	0
1.3400	0
1.3500	0.0100
1.3600	0.0200

A put option has an intrinsic value if the current market price of the underlying value is lower than the exercise price. If the price of the underlying value is the same or higher than the exercise price, the intrinsic value of a put option is zero. In the table below, the intrinsic value of a GBP put / USD call option with a strike price of GBP / USD 1.2200 is shown.

Spot rate	Intrinsic Value
1.2000	0.0200
1.2100	0.0100
1.2200	0
1.2300	0
1.2400	0

Time value

The value of an option is always equal to or greater than the intrinsic value. This is because of the fact that during the remaining term of the option the intrinsic value can change either upwards or downwards. And the probability that the intrinsic value increases during the remaining term is always larger than the probability that the intrinsic value decreases. The difference in these two probabilities is represented by the time value also called expectations value. The option premium is the sum of the intrinsic value and the expectation value. This is shown in the following equation :

Option premium = Intrinsic value + Time value

The table below shows the development of the option premium of a GBP call / USD put option with a strike price of 1.6000 and a remaining term of three months for different GBP/USD FX forward rates.

GBP/USD forward rate	Intrinsic Value	Time value	Option Premium
1.5000	0	0.0125	0.0125
1.5500	0	0.0260	0.0260
1.6000	0	0.0475	0.0475
1.6500	0.0500	0.0260	0.0760
1.7000	0.1000	0.0125	0.1125

The time value is determined by the difference in the chance that the intrinsic value will increase and the chance that the intrinsic value will decrease during the remaining term of the option contract. Both probabilities depend on how the price of the underlying value might develop during the remaining term of the option contract. To make an estimation of this development, a stochastic distribution is used, for instance a (log-)normal distribution. The time value is for the greatest part determined by three parameters:

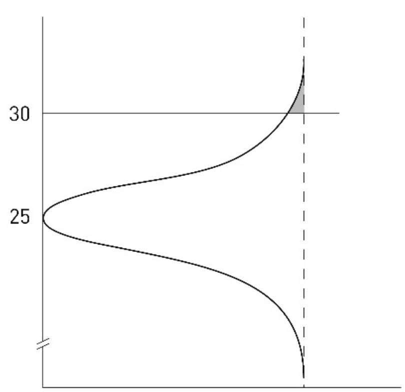
- the price of the underlying value;
- the remaining term of the option contract;
- the volatility of the underlying value.

Volatility is a measure which indicates the degree of price movements of a rate or price. A low volatility indicates that prices or rates do not change much whereas a high volatility indicates that prices move considerably. The potential revenue of an option depends on the chance that an option will be exercised and the level in which the option is in-the-money at that moment. Volatility has an impact on both of these factors, i.e. if the volatility is high, for instance, then both the chance that the option will become in-the-money and how much the option will be in-the-money increase. This means that option premiums are higher in case of higher volatilities.

We will now discuss the relationship between the price determining parameters of options and the option premium. As an example we use a call option with a strike of 30. The diagrams below are based on the Black-Scholes model which assumes that prices and rates on the financial markets follow a (log-)normal probability distribution.

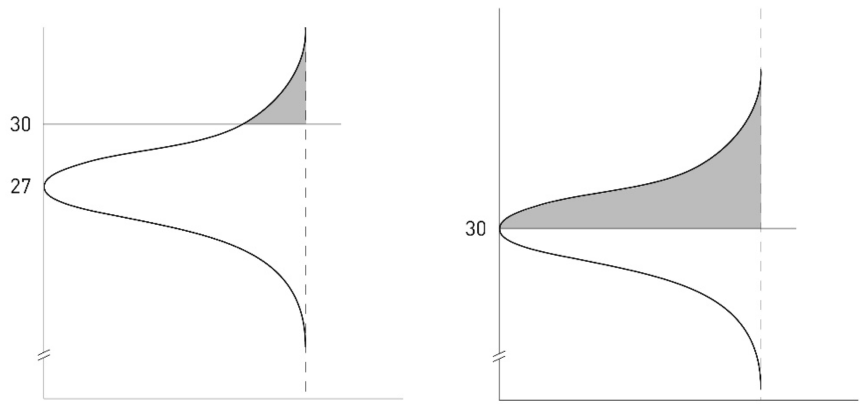
Figure 6.1 shows the range of possible movements of the price of an underlying value during the remaining term (according to a normal probability distribution) for a call option with a strike price of 30 if the current price of the underlying value is 25. Because the current spot rate is lower than the strike price of the call option, the intrinsic value of this option is zero. The chance that the option will end up in-the-money and thus will become to have an intrinsic value is represented by the shaded area above the strike level. Since the option has no intrinsic value, the downward potential for the intrinsic value is zero. The time value of this option therefore is completely determined by the shaded area above the strike level.

Figure 6.1 Time value of a call option with a strike of 30 if the price of the underlying value is 25.



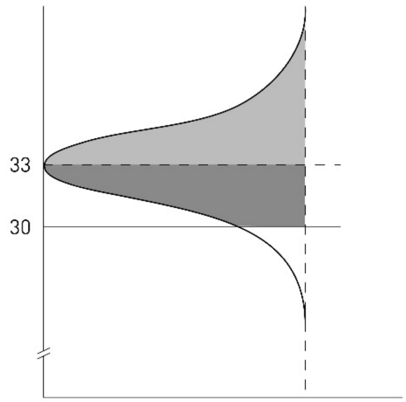
If the price of the underlying value increases then the time value of an out-of-the-money call option will also increase. After all, the upward potential for the intrinsic value increases whereas the downward potential is still zero. Note that the intrinsic value of an out-of-the-money option is always zero. This is shown in figure 6.2 for prices of the underlying value of 27 and 30.

Figure 6.2 Time value of a call option with a strike of 30 if the price of the underlying value is 27 and 30



If the price of the underlying value increases above the strike price, then the option will start to have an intrinsic value. This means that, from that moment, there is not only an upward potential for the intrinsic value, but also a downward potential. After all, the holder of the option can now also lose his intrinsic value. Figure 6.3 shows the time value of the call option if the price of the underlying value is 33. The upward potential for the intrinsic value is represented by the light shaded area and the downward potential is represented by the dark shaded area. The expectation value, i.e. the difference between the upward and the downward potential of the intrinsic value, is represented by the non-shaded area below the horizontal line which represents the strike price of 30.

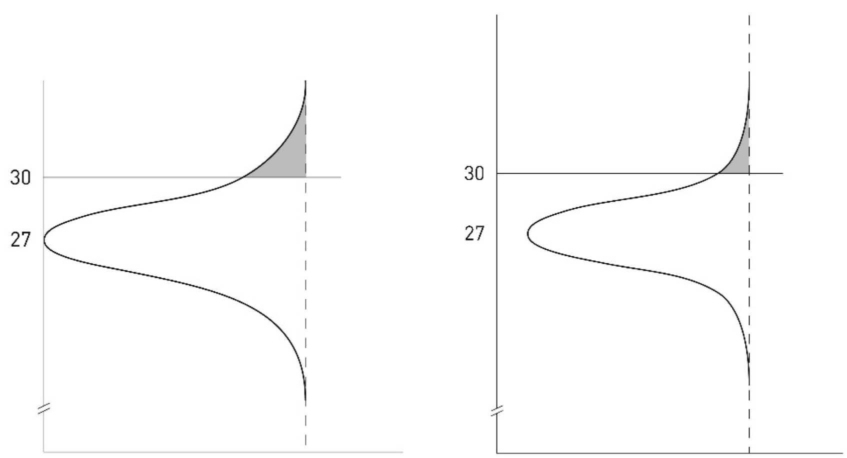
Figure 6.3 Time value of a call option with a strike of 30 if the price of the underlying value is 33



Although the time value of in-the-money call options decreases if the price of the underlying value increases, the total value of the option still increases. This is because of the fact that the intrinsic value increases and that the increase in the intrinsic value is always larger than the decrease of the time value.

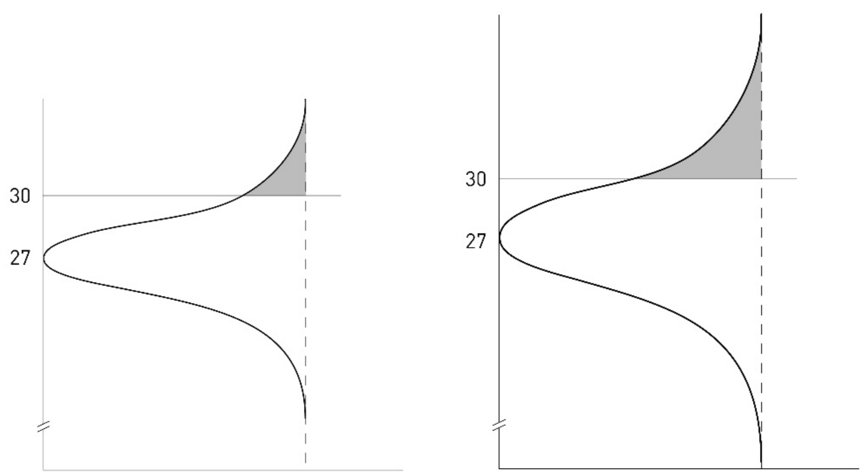
The second parameter of the time value is the remaining term. During the term of the option contract, the time value decreases. The reason for this is that, during the term of the option contract the diagram which represents all the possible price movements of the underlying value moves to the right. This is shown in figure 6.4. The time value is again represented by the shaded area.

Figure 6.4 Time value of a call option with a strike of 30 for different remaining terms



During the term of an option contract, the volatility changes constantly. If the volatility of the underlying value increases, then the time value will also increase. In figure 6.5 the increase in the volatility is represented by a wider shape of the curve.

Figure 6.5 Time value of a call option with a strike of 30 for different volatilities



In the table below we summarize the relationships between the price determining parameters and the option premium.

Price determining parameter	Higher	Lower

Price of the underlying in case of a **call** option	Option premium ↑	Option premium ↓
Price of the underlying in case of a **put** option	Option premium ↓	Option premium ↑
Volatility	Option premium ↑	Option premium ↓
(Remaining) term	Option premium ↑	Option premium ↓

6.2 The interpretation of the market value

The market value of non-option derivative contracts is, in principle, zero on the moment on which they are concluded. However banks charge spreads to cover their credit risk and their costs and, on top of that, take some profit. Because of this the market value at the start of a derivative contract is usually positive for the bank and negative for the client. Let us assume, for instance, that the current EUR/USD forward rate is 1.2510 and hat the bank charges a client spread of 0.0010. If a client wants to conclude an FX forward in which it buys USD 1,000,000 (sells euro), then the bank will set the contract rate at 1.2500 instead of 1.2510. According to the contract, the client would have to pay 1,000,000 / 1.2500 = 800,000 euros. If the market rate would have been applied, this would only be 1,000,000 / 1.2510 = EUR 799,360. This means that the market value of the FX forward contract at the start date immediately is negative; i.e. minus 640 euro.

During the contract term, the market value of a derivatives contract changes constantly and it can become positive or (more) negative. We will now discuss what the consequences are of a negative market value. Our first remark would be that a negative market has no impact whatsoever on the future cash flows of the market party resulting from the transacted contract. A negative market value means nothing more for a market party other than the fact that he still has to comply with the obligations resulting from the contract, which in retrospect are not so favourable. The negative market value merely means that the market party could have concluded a deal under better conditions now than the conditions which were prevailing on the moment that he or she concluded the transaction. In other words: a negative market value only represents an opportunity loss.

If a derivative contract has a negative market value, this has no impact on the future cash flows that are agreed in the contract, but it may have an impact on the liquidity position of the market party. This is because sometimes banks apply a margin system which means that a client is required to deposit an amount of money with the bank that is equal to the negative market value. The reason why banks apply a margin system is because they want to cover the risk of default of their clients. They will pay the margin back if the market value of the contract increases or at the maturity date of the contract, once the client has fulfilled the obligations as a result of the derivative transaction. This means that the effect on the liquidity position of the client is only temporary.

Options are rights and this means that the value of an option is always positive. If a client of a bank buys an option, then he or she must pay a premium. The premium represents the market value of the option; positive for the buyer of the option and negative for the seller (after all during the option term only the seller has a potential future obligation; the buyer has already fulfilled his obligation by paying the option premium on the start date of the option contract).