Option pricing

Information provided is for educational purposes and does not constitute financial product advice. You should obtain independent advice from an Australian financial services licensee before making any financial decisions. Although ASX Limited ABN 98 008 624 691 and its related bodies corporate ("ASX") has made every effort to ensure the accuracy of the information as at the date of publication, ASX does not give any warranty or representation as to the accuracy, reliability or completeness of the information. To the extent permitted by law, ASX and its employees, officers and contractors shall not be liable for any loss or damage arising in any way (including by way of negligence) from or in connection with any information provided or omitted or from any one acting or refraining to act in reliance on this information.

© Copyright 2013 ASX Limited ABN 98 008 624 691. All rights reserved 2013.

All Ordinaries®, All Ords®, AllOrds®, ASX®, ASX100®, CHESS®, ITS® are registered trademarks of ASX Operations Pty Limited ABN 42 004 523 782 ("ASXO").

ASX20™, ASX50™, ASX200™, ASX300™ are trade marks of ASXO.

S&P™ is a trademark of Standard and Poor's, a division of The McGraw-Hill Companies Inc.

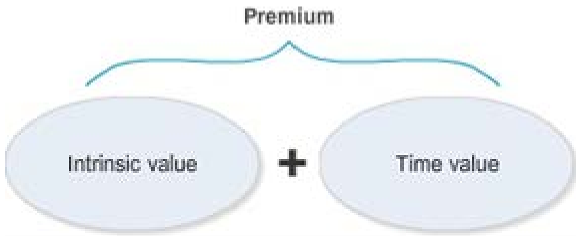
Topic 1: Intrinsic value and time value

An option's premium is the only element of the option not specified by ASX.

It is influenced by a number of factors, including the price and volatility of the underlying stock, the option's exercise price and the time until expiry.

An option's premium can be broken into two parts, intrinsic value, and time value:

Premium = intrinsic value + time value



Intrinsic value

Intrinsic value is the difference between the option's exercise price and the current share price. It cannot be less than zero. An option invariably trades at no less than intrinsic value.

Call options have intrinsic value if the share price is above the exercise price. Put options have intrinsic value if the share price is below the exercise price.

Current share price: $25.20	
Option	**Intrinsic value**
24.00 call	$1.20
25.00 call	$0.20
25.00 put	$0.00
26.00 put	$0.80

If the share price is $10.50:

- a $10.00 call has $0.50 intrinsic value
- an $11.00 call has no intrinsic value
- an $11.00 put has $0.50 intrinsic value
- a $10.00 put has no intrinsic value

An option has intrinsic value if exercising the option would result in you buying or selling the shares at a price better than the current share price.

In-the-money, out-of-the-money, at-the-money

There is a 'shorthand' commonly used to refer to options, according to the option's strike price and the current share price. It's worth being familiar with these terms:

- In the money (ITM) - share price is above the strike price of a call, or below the strike price of a put
- Out of the money (OTM) - share price is below the strike price of a call, or above the strike price of a put
- At the money (ATM) - share price is the same as, or close to, the strike price.

Current share price: $4.80				
Option type	Exercise price	Premium	Intrinsic value	Time value
call	4.50	0.45	0.30	0.15
call	5.00	0.17	0.00	0.17
put	5.00	0.33	0.20	0.13

Time value

Before expiry, an option will usually trade for more than its intrinsic value.

The part of the premium over and above its intrinsic value is time value.

For example, if in May XYZ shares are trading at $10.30, the XYZ June $10.00 call might be trading at $0.55.

Of this, $0.30 is intrinsic value, the remaining $0.25 is time value.

When an option is out of the money, or at the money, it has zero intrinsic value, and the premium is made up entirely of time value.

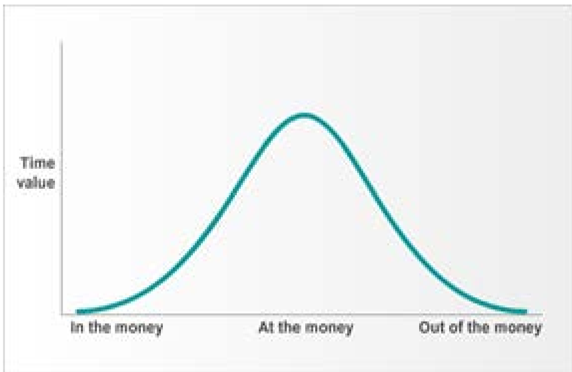
Options with the same time to expiry may have different time value.

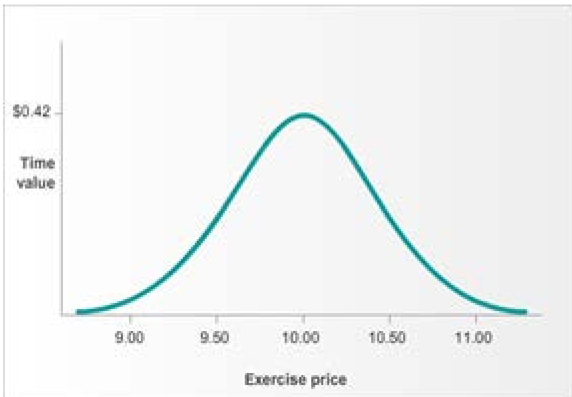
There is a relationship between an option's strike price and its time value.

The ATM option has the most time value. The further the strike price is from the current stock price, the less time value the option has.

With XYZ shares trading at $10.00 in May, June call options might be trading as follows:

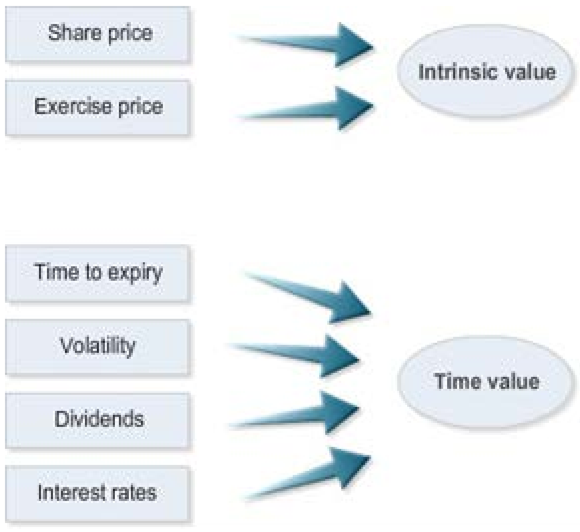
- $9.00 strike: premium $1.14 - intrinsic value $1.00, time value $0.14
- $9.50 strike: premium $0.73 - intrinsic value $0.50, time value $0.23
- $10.00 strike: premium $0.42 - intrinsic value $0.00, time value $0.42
- $10.50 strike: premium $0.21 - intrinsic





value $0.00, time value $0.21

- $11.00 strike: premium $0.09 - intrinsic value $0.00, time value $0.09



Time value is a fundamental concept in option trading.

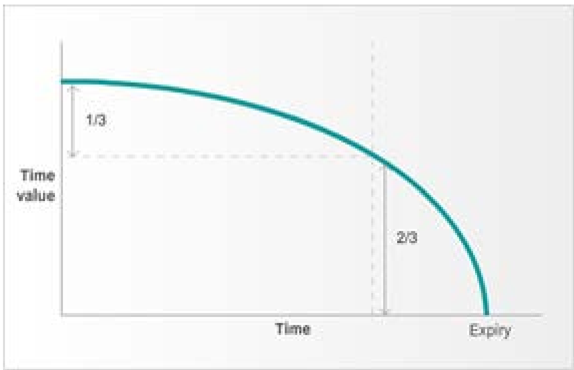
Shares do not have a time value component, as they have no expiry date. Options, on the other hand, are a wasting asset, and an important part of their value is the time remaining in the option's life.

Next we'll look at the factors that influence an option's time value:

- time to expiry
- volatility of the underlying shares
- dividends
- interest rates.

Topic 2: What affects an option's time value?

Time to expiry



The longer the time to expiry, the greater an option's time value (both calls and puts), all other things being constant.

When you buy an option, you want the underlying shares to move as far as possible in your favour. The longer the time remaining, the greater the chance of this happening, and so the more you must pay for the option.

As time passes, the option's time value decreases, in a process called 'time decay'.

At expiry, an option has no time value, only intrinsic value.

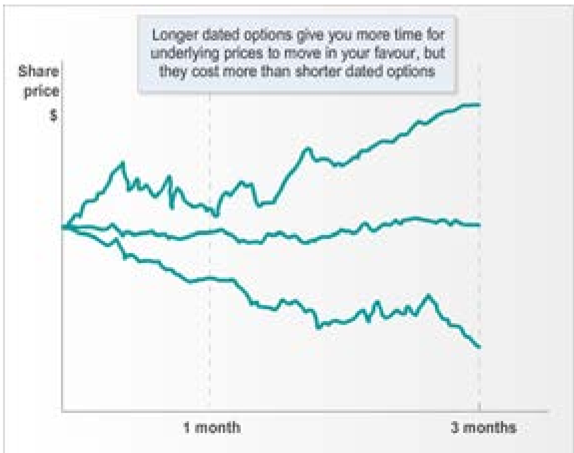
Time decay is not constant. In the early stages of an option's life it tends to be gradual, and accelerates as expiry approaches.

A rule of thumb is that an option loses one-third of its time value during the first half of its remaining life, and two-thirds during the second half.

When you buy an option, time decay works against you.

The increase in the pace of time decay over the option's life means the period approaching expiry is the most damaging. Even though the share price may not move, the option will lose value due to time decay.

In choosing between expiry months, you must balance the cost of the option against the time needed for the strategy to work.



The longer the time to expiry, the greater the opportunity for the share price to move further in your favour.

However, extra time comes at a cost. You will pay more for a longer term option than for a shorter term option.

Choice of expiry month is covered in more detail in later modules on option strategies.

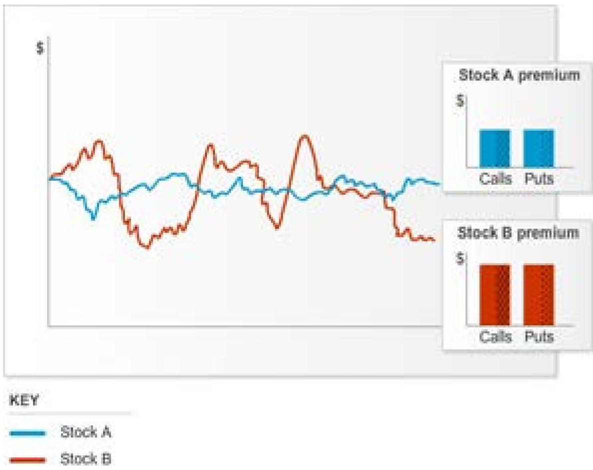
Volatility

The more volatile the stock, the higher the option's premium, all else being equal.

Volatility refers to the size and speed of movements in the share price - in other words, how far and how fast the price tends to move, either up or down.

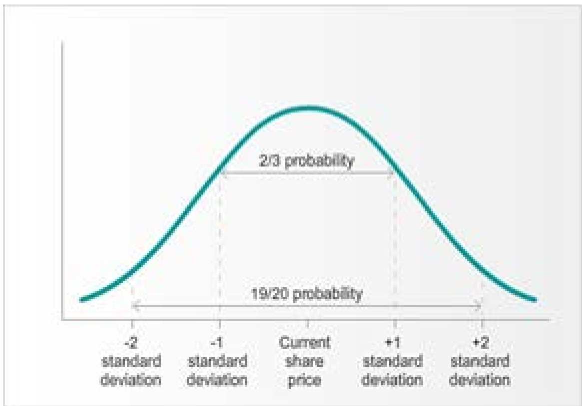
Volatility varies considerably between stocks listed on ASX. Some stocks tend to be volatile, their price moving over a wide range in a short period of time, while others are more stable.

Volatility also varies over time. A stock may trade steadily within a range for a while, before entering a period of significant price movement.



Volatility works in favour of the option holder. The more volatile a stock, the greater the chance of a big move in the share price - and therefore the more you are prepared to pay for the option.

The option writer is exposed to higher risk of a damaging share price movement, and expects a higher premium to compensate for that risk.



Increased volatility increases the size of likely stock price movements both up and down, so higher volatility increases both call and put premiums.

Volatility is expressed as an annualised percentage figure (the annualised standard deviation of daily percentage changes in a stock's price).

Much options pricing theory is derived from probability theory, and assumes that share price changes (in percentage terms) are normally distributed.

This means we can use a stock's volatility and current price to predict the likely trading range over the next year.

Probability theory tells us that after a year there is a probability of roughly:

- 2 in 3 that the share price will be within one standard deviation of the current share price [share price +/- (1 x volatility)].
- 19 in 20 that the share price will be within two standard deviations of the current share price [share price +/- (2 x volatility)].

Let's look at an example.

A stock trading at $10.00 might have a volatility of 30%.

Using our rules from the previous screen, after one year there is a probability of roughly:

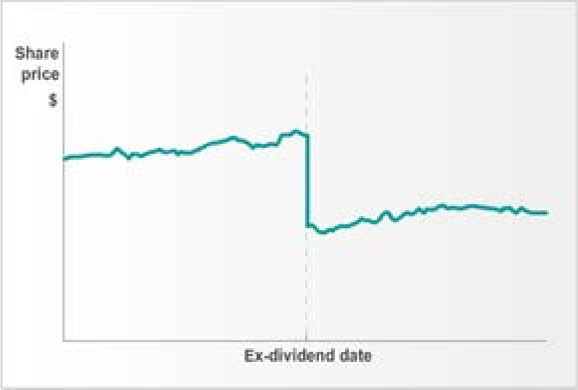
- 2 in 3 that the shares will be between $7.00 and $13.00 ($10.00 +/- 30%)
- 19 in 20 that the shares will be between $4.00 and $16.00 [$10.00 +/- (2 x 30%)]

The detailed mathematics of volatility are beyond the scope of this module, but many option textbooks cover the topic at length.

	Volatility	2/3 probability trading range	
		Low	High
Stock price = $20.00	20%	$16	$24
	30%	$14	$26
	40%	$12	$28

Topic 3: What affects an option's time value? (cont.)

Dividends



If the stock goes ex-dividend during the option's life, option pricing is affected. This is because the price of the stock itself usually changes.

All else remaining constant, on the ex-dividend date the stock price usually falls by the amount of the dividend. The stock no longer 'contains' the dividend.

If this happens during the option's life, the stock price at expiry will be lower than it would have been if the stock had not gone ex-dividend.

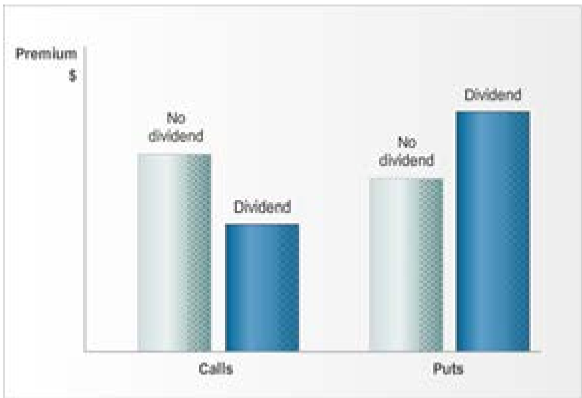
(The date the dividend is paid is irrelevant - it is the date that the stock is no longer entitled to the dividend that matters.)

The stock price changes on the ex-dividend date, but the effect of the dividend is priced into options well ahead of the ex-dividend date.

All else being equal, the option price should not change much from the cum-dividend date to the ex-dividend date.

However, if a company announces a dividend larger or smaller than expected, option prices will be affected, as the dividend 'priced into' the option has changed.

You can check declared dividends on the ASX website.



Call and put premiums are affected differently.

If the stock goes ex-dividend during the option's life, call premiums will be lower, and put premiums higher, than if the stock does not go ex-dividend during this period.

Call buyers want to see the stock price as high as possible at expiry. Since the stock falls in price on going ex-dividend, the call buyer will not be prepared to pay as high a premium.

Put options are worth more, the lower the stock price is, so the put buyer is prepared to pay more if the ex-dividend date falls within the option's life.

Interest rates

When you buy a call, the premium you pay is a small percentage of the value of the underlying shares. You don't have to pay for the shares themselves unless you exercise the option - which can be deferred until the expiry date. During this time, you can invest those funds and earn interest.

Interest rate	Call option
↑	↑
↓	↓

The call option has a funding benefit, the value of which is reflected in the option premium.

The higher interest rates are, the greater the funding benefit is, and the higher call premiums will be.

When you buy a call, you defer the expenditure of funds. When you buy a put, you defer the receipt of funds. It is not until you exercise a put option that you receive money for the shares. In the meantime it is assumed you are funding the shareholding.

Interest rate	Call option	Put options
↑	↑	↓
↓	↓	↑

The higher interest rates are, the greater the cost of funding - and so the less you will be prepared to pay for the put.

Increases in interest rates lead to higher call premiums and lower put premiums, all else being equal.

Topic 4: How much should I pay for an option?

Option pricing models

Trader knows	Trader estimates
Current share price	Interest rates
Exercise price	Dividends
Days to expiry	Volatility

An option pricing model is a formula that produces a theoretical or 'fair' value for an option, based on values for each of the variables we have just looked at.

The theoretical fair value of an option is not necessarily the same as its current market price!

Traders use pricing models to help assess whether options are fairly priced in the market, and to guide them in their trading strategies.

It's useful to know a little about how traders calculate option values, but you don't have to become an expert in using pricing models in order to trade options. A well known pricing model is the Black & Scholes.

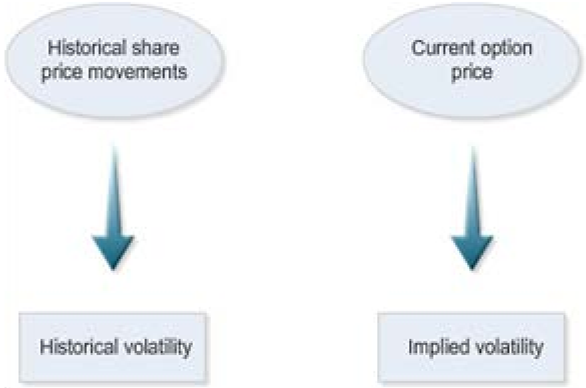
Some variables affecting option values are easily quantified, but others reflect assumptions made by the trader using their model.

The option exercise price, the current share price and the days to expiry are known precisely. Volatility of the underlying shares, interest rates and dividends must be estimated.

The most difficult to estimate and important of these is volatility.

The trader must make an assumption of how the stock price will behave over the option's life. There is no way of knowing whether that assumption is accurate until the expiry date.

Historical and implied volatility



Traders often use a stock's ***historical volatility*** in their pricing calculations. Historical volatility is the stock's actual volatility measured over a designated period in the past. In taking this approach, the trader assumes that the stock price will behave in the future as it has done in the past.

Traders also look at an option's ***implied volatility***. This is the volatility assumption behind the current market price of the option - the volatility figure that must be used in a pricing model to produce an option value the same as the current market price.

You can think of implied volatility as the market's consensus forecast of the stock's volatility over the life of the option.

The volatility referred to earlier in Topic 2 of this module is historical volatility.

Traders may then make a judgement as to whether an option is overvalued (implied volatility relatively high) or undervalued (implied volatility relatively low).

Trader's assessment of implied volatility	Possible action
Low	Buy options
High	Write options

This may result from a comparison of implied volatility with historical volatility, or with the trader's forecast volatility over the option's life.

If the trader thinks the option is mispriced, they can implement an option strategy to exploit this.

If a trader thinks options are undervalued, strategies involving bought options may be more attractive. If the trader judges that options are overvalued, they may prefer strategies involving written options.

ASX Option Pricing Calculator

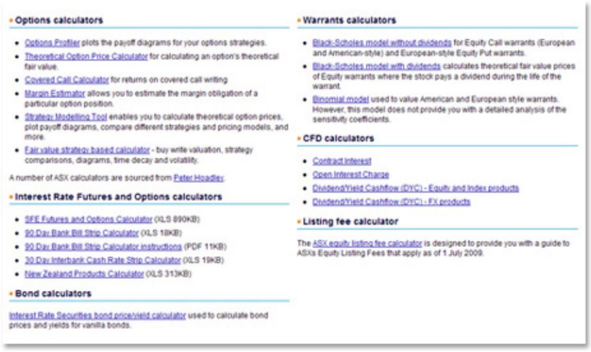
The ASX website contains a Theoretical Option Price Calculator.

The Calculator automatically inserts default values for the variables that affect an option's price, including ASX estimates of dividends and volatility.

You can also insert your own values for volatility and other variables to see how the theoretical option value is affected.

ASX's publishes dividend and volatility estimates for option stocks. The volatility figure is a weekly, weighted approximation of implied volatility on all option orders in that stock.

The Strategy Modelling Tool is another tool you can use to calculate option prices, as well as model various option strategies.



Options calculators

- Options Profiler plots the payoff diagrams for your options strategies.
- Theoretical Option Price Calculator for calculating an option's theoretical fair value.
- Covered Call Calculator for returns on covered call writing
- Margin Estimator allows you to estimate the margin obligation of a particular option position.
- Strategy Modelling Tool enables you to calculate theoretical option prices, plot payoff diagrams, compare different strategies and pricing models, and more.
- Fair value strategy based calculator - buy write valuation, strategy comparisons, diagrams, time decay and volatility.

A number of ASX calculators are sourced from Peter Hoadley.

Interest Rate Futures and Options calculators

- SFE Futures and Options Calculator (XLS 890KB)
- 90 Day Bank Bill Strip Calculator (XLS 18KB)
- 90 Day Bank Bill Strip Calculator instructions (PDF 11KB)
- 30 Day Interbank Cash Rate Strip Calculator (XLS 19KB)
- New Zealand Products Calculator (XLS 313KB)

Bond calculators

Interest Rate Securities bond price/yield calculator used to calculate bond prices and yields for vanilla bonds.

Warrants calculators

- Black-Scholes model without dividends for Equity Call warrants (European and American-style) and European-style Equity Put warrants.
- Black-Scholes model with dividends calculates theoretical fair value prices of Equity warrants where the stock pays a dividend during the life of the warrant.
- Binomial model used to value American and European style warrants. However, this model does not provide you with a detailed analysis of the sensitivity coefficients.

CFD calculators

- Contract Interest
- Open Interest Charge
- Dividend/Yield Cashflow (DYC) - Equity and Index products
- Dividend/Yield Cashflow (DYC) - FX products

Listing fee calculator

The ASX equity listing fee calculator is designed to provide you with a guide to ASXs Equity Listing Fees that apply as of 1 July 2009.

Topic 5: Delta

As well as producing an option's fair value, an option pricing model provides other useful information.

	Today	Tomorrow
Share	$10.00	$10.20
Option	$0.42	???

Professional traders use sensitivity measures known as the "Greeks" to work out how much risk their portfolio is exposed to, and where that risk lies.

For the private investor, **delta** can be useful.

Delta is a measure of an option's sensitivity to a change in the price of the underlying shares. If the share price moves by a certain amount, how might that affect the value of your option?

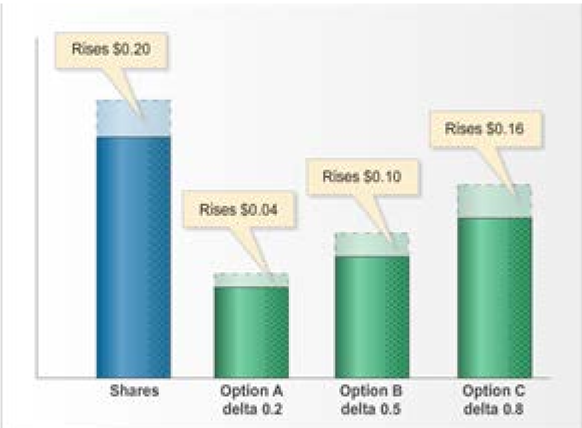
The delta of a call option is between zero and 1 (or it may be expressed as a percentage).

Share price movement x option delta = likely change in option price

So, if your option has a delta of 0.6, and the share price rises by $0.10, you would expect your option to rise by $0.06.

If the share price falls by $0.20, you would expect your option to fall by $0.12.

Options with different strikes have different deltas:



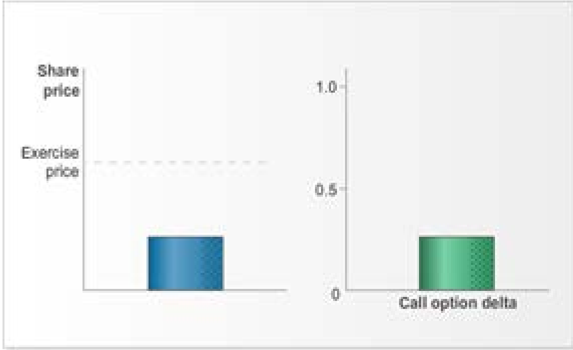
- An at-the-money call usually has a delta of around 0.5.
- The further out of the money an option is, the closer the delta is to zero.
- The deeper in the money an option is, the closer the delta is to 1.

So different options have different sensitivities to share price movements.

A deep in-the-money option with a delta of 0.9 will be very responsive to share price changes, moving almost cent for cent.

A far out-of-the-money option with a delta of 0.1, however, will not react very much at all to share price movements.

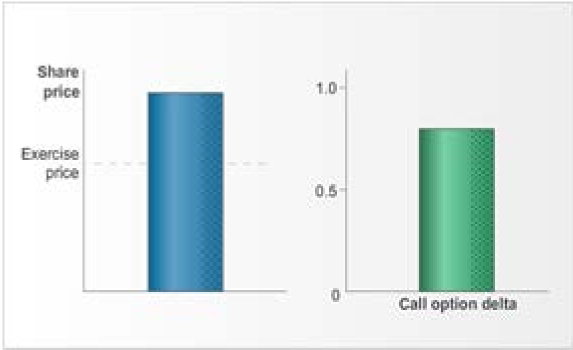
As the share price changes, the option's delta changes.



Assume you buy an $11.00 call with the shares trading at $10.00. The option is well out of the money, and has a delta of 0.2.

Initially, the option is not very sensitive to share price changes. But as the share price rises, the option's delta increases.

If the share price hits $11.00, the option is at-the-money. If it reaches $12.00, the option is well in the money, and may have a delta of around 0.9.

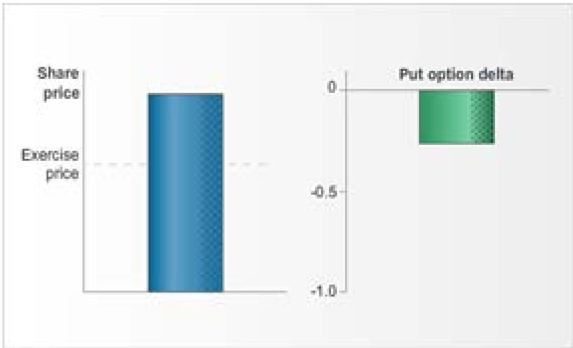


As the share price rises, delta increases, and the option picks up value at an accelerating rate.

This is the ideal scenario for a call buyer.

Put option deltas

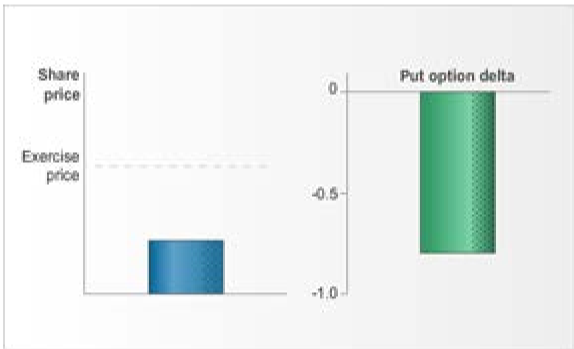
Put option deltas are negative, because the option price moves in the opposite direction to the share price. As the share price rises, the put falls in value; as the share price falls, the put rises in value.



A put has a delta between zero and -1.

If your put option has a delta of -0.4, and the share price falls by $0.10, the option should rise by about $0.04.

An at-the-money put has a delta of around -0.5. The further out of the money a put is, the closer the delta is to zero. The deeper in the money a put is, the closer the delta is to -1.



Summary

An option's premium comprises intrinsic value and time value.

An option's *intrinsic value* is the difference between the exercise price and the current share price. A call has intrinsic value if the share price is above the strike price; a put has intrinsic value if the share price is below the strike price.

An option's *time value* is affected by:

- time to expiry
- volatility of the underlying shares
- dividends, and
- interest rates.

An option is a wasting asset. All other things being constant, as time passes, the time value of an option falls. At expiry, the option is worth intrinsic value only.

You can use an option pricing model to calculate an option's theoretical fair value. Pricing models produce values based on the variables that affect an option's premium.

The theoretical fair value is not necessarily the same as the option's market price.

An option's *delta* indicates how the option will react to a change in the share price:

Change in option price = change in share price x delta

An option's delta is between 0 and 1. Call options have positive deltas, put options have negative deltas.

Option prices used in this module

Practical examples of option strategies are given throughout this module.

Option prices used in the examples were calculated using a binomial pricing model.

Unless specified otherwise, prices are based on the following:

- Underlying stock price: $10.00
- Volatility: 25%
- Risk free interest rate: 6%
- Days to expiry: 52
- The stock does not go ex-dividend during the life of the option

Keeping these assumptions constant in all examples should make it easier to compare the different strategies presented.