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RATES UNIVERSITY

08. Options Basics

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Contents

This module is an introduction to the theory and practice of Options.

We will look at the following theoretical concepts ...

- Option definitions
- Call and Put payoffs
- Volatility
- Black Scholes pricing
- Put / Call Parity

We will then consider at some specific option examples ...

- Call and Put Spreads
- Caps & Floors

Option Definitions

An Option is the right, but not the obligation, to buy (Call) or sell (Put) an asset at a specified date at a specified price.

Note the difference to a Forward which is the obligation to buy (or sell) an asset at a specified future date at a specified price.

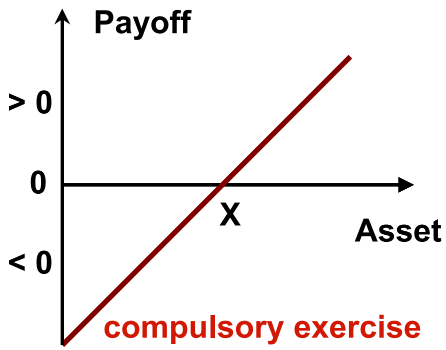
A Forward obliges the participants to transact the agreed exchange on the agreed date at the agreed price.

An Option by contrast allows the Option Buyer to choose to exercise the exchange (a purchase or a sale) or not, depending upon the real or perceived value of that purchase or sale.

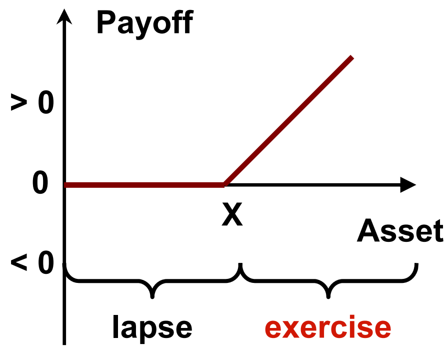
The difference is readily seen when we look at the Payoffs at Maturity of both

- a long Forward Position (an obligation to buy the asset for X on the Forward Date)
- a long Call position (a right, not obligation, to buy the asset for X on the option Maturity Date)

Long Forward



Long Call



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Option Definitions

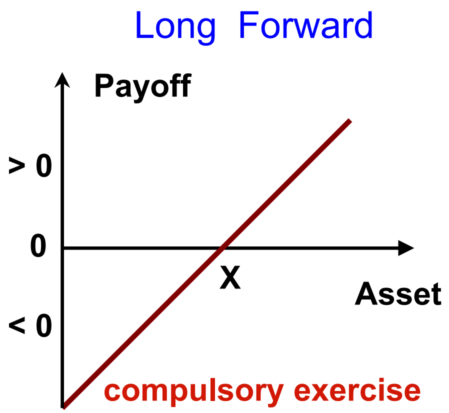
A Long Forward position can result in both positive and negative payoffs.

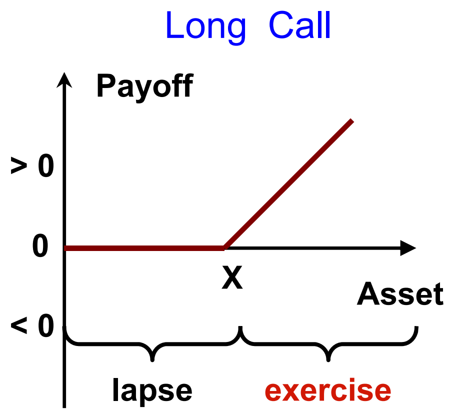
- If the Asset finishes above the Forward Price X then the payoff is positive.
- If the Asset finishes below the Forward Price X then the payoff is negative

A Long Call position however can only have a non-negative payoff (>=0).

- if the Asset finishes above the strike X the option holder will exercise the right to buy the Asset for X and receive the Payoff Asset - X
- if the Asset finishes below the strike X the option holder will not exercise the right to buy the Asset for X. To buy the Asset for X would result in a loss since the Asset is cheaper in the market. The Payoff of an unexercised option would be 0.

The Option thus has an asymmetric payoff that protects the holder against adverse movements in the Asset Price. This protection comes at a cost however … the option buyer needs to pay a premium in cash upfront.





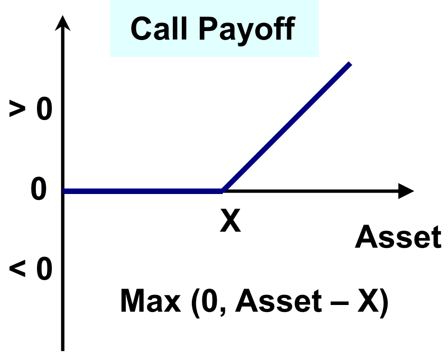
Option Definitions

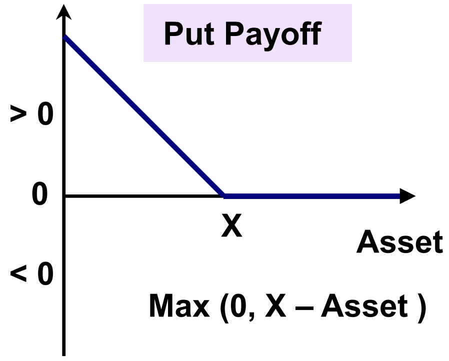
The basic option contracts are Calls and Puts.

Call Option	the buyer of a Call Option has the right to buy the underlying asset on a specified date at a specified price (the strike)
Put Option	the buyer of a Put Option has the right to sell the underlying asset on a specified date at a specified price (the strike)
Strike	the price at which the asset is bought or sold if the option is exercised

Both Calls and Puts allow the holder of the option the right to exercise if the payoff of doing so is positive. Conversely, they also allow the holder to opportunity to let the option expire unexercised.

The Payoffs are Call Payoff = Max (0, Asset – X) where X = Strike
Put Payoff = Max (0, X – Asset)





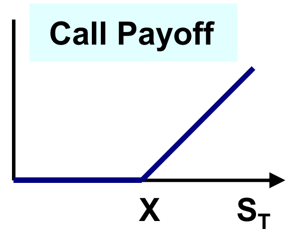
Payoffs and Volatilities

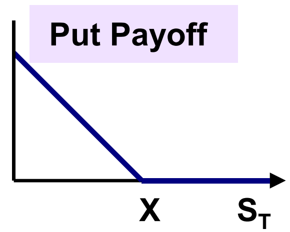
The Payoffs for Calls and Puts are given by

Call Payoff = Max (0, S_T – X)

where …
S_T = the asset price at Maturity (time T)
X = the strike

Put Payoff = Max (0, X – S_T)





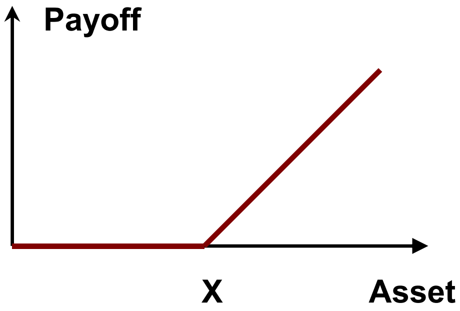
A key component of Options pricing is the assumed volatility of the underlying variable or asset. We look at the definitions …

Volatility	a measure of the variability of the price of the underlying Asset or Index In Black-Scholes, Lognormal Volatility is technically the standard deviation of the Log of the Asset Price in 1 year's time. Lognormal Vol is also effectively the standard deviation of the percentage change in the asset price over 1 year. For interest rate options, Basis Point Vol is the standard deviation of the absolute change in the interest rate Index over 1 year.
Historical Vol	the historical vol is the observed volatility of the asset price over a specified period.
Implied Vol	the implied vol is the volatility implied by the option price traded in the market. The implied vol may be higher or lower than the historical vol. Note that implied vol is in a sense forward looking, historical vol backwards looking

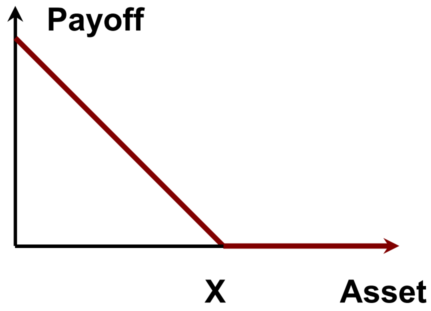
Both Puts and Calls become more valuable when the implied volatility increases.
This is because higher volatility implies a higher probability of finishing deep in the money

Calls and Puts … Long & Short

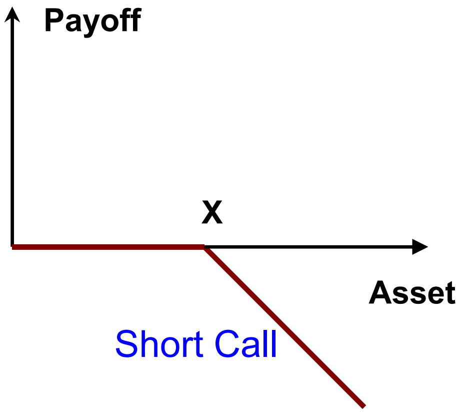
There are 4 basic payoff diagrams for Calls and Puts …



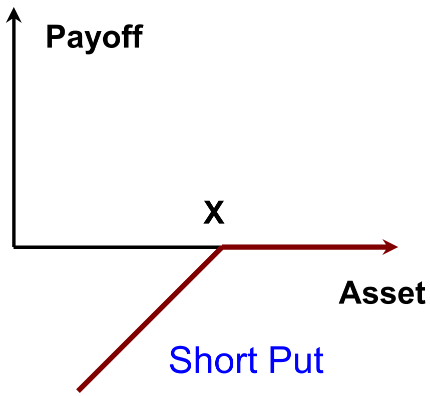
Long Call



Long Put



Short Call



Short Put

European Options

European Options have a well-established analytical valuation methodology.
This theory is called Black-Scholes Theory

Black-Scholes Theory was developed in the 1970s and was the first truly comprehensive solution to the problem of European option valuation.

Under a set of assumptions about the distribution of the underlying asset (interest rates, FX rates etc), about the volatility of the asset, etc, the theory uses arbitrage arguments to derive analytical formulas for calls and puts.

In the Black-Scholes world, Geometric Brownian Motion is assumed as the dynamic model for the evolution of the underlying asset.

The variable could be for example

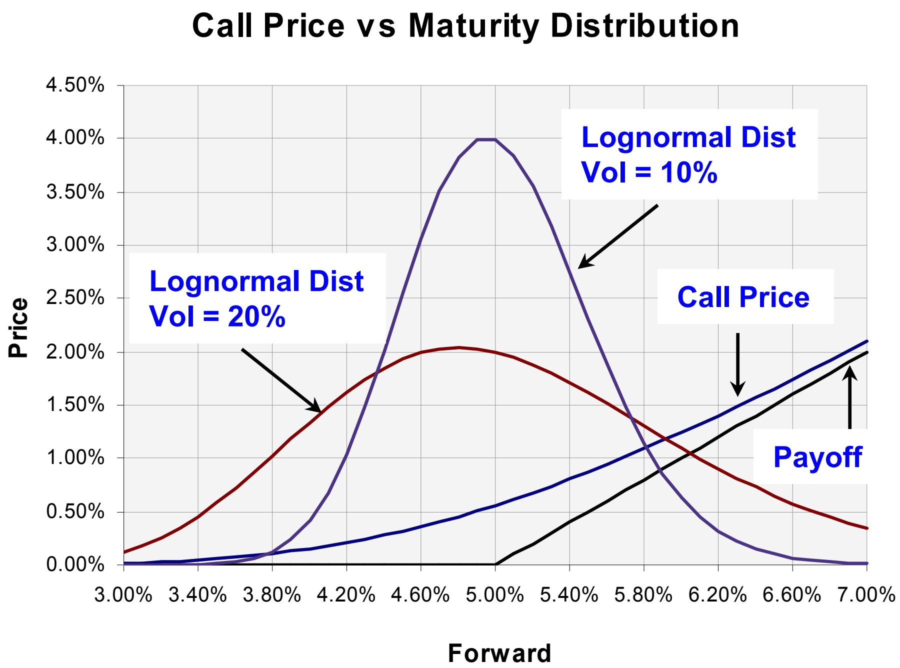
- a short term interest rate
- a spot FX rate
- an observable Index
- a commodity price, etc.

Black-Scholes Methodology

Black and Scholes proved that, under certain assumptions, an underlying asset could perfectly hedge the profits and losses of a standard European option by following a self-financing dynamic replication portfolio strategy.

The Black-Scholes European option price is the discounted expected payoff of the option at Maturity and is derivable analytically since the distribution of the underlying variable at the sole exercise date is available.

This is of course intuitively appealing. Under Geometric Brownian motion the distribution of the underlying at Maturity is Lognormal. This distribution can be used to calculate the expected value of the option payoff. Since this payoff occurs at Maturity it must be discounted in order to calculate the option value (premium)



The graph shows the Call Price and Payoff for a Call with as functions of the Forward. Also shown are the Lognormal Distributions corresponding to 10% and 20% volatilities.

The Call is priced using a volatility of 20%

If the Call were repriced using only 10% vol then the Call price would fall.

This is because the payoff is asymmetric. A higher vol implies a greater chance of extreme positive payoffs.

Intrinsic Value and Time Value

Intrinsic Value is the gain that could be realised through immediate exercise of the option.
For a Call this is Max (0, Asset – Strike)

Time Value is the remaining value of the option.
It captures the potential additional payoff from the underlying moving (deeper) into the money before expiry.

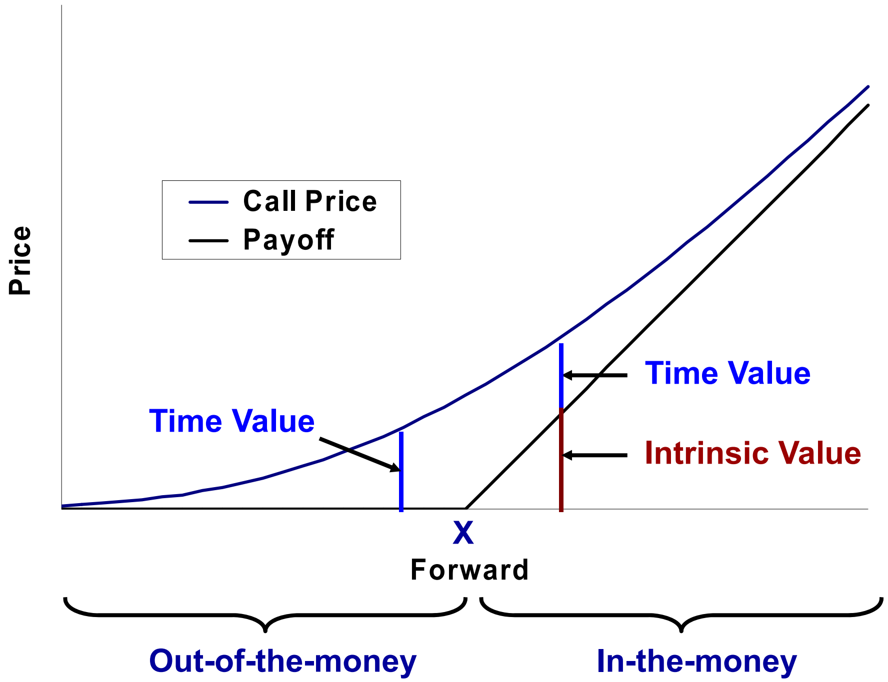
The graph shows both the Call Price and Payoff for a Call with Strike X, as functions of the Forward Rate.

The Call Price is divided into …
- Intrinsic Value
- Time Value

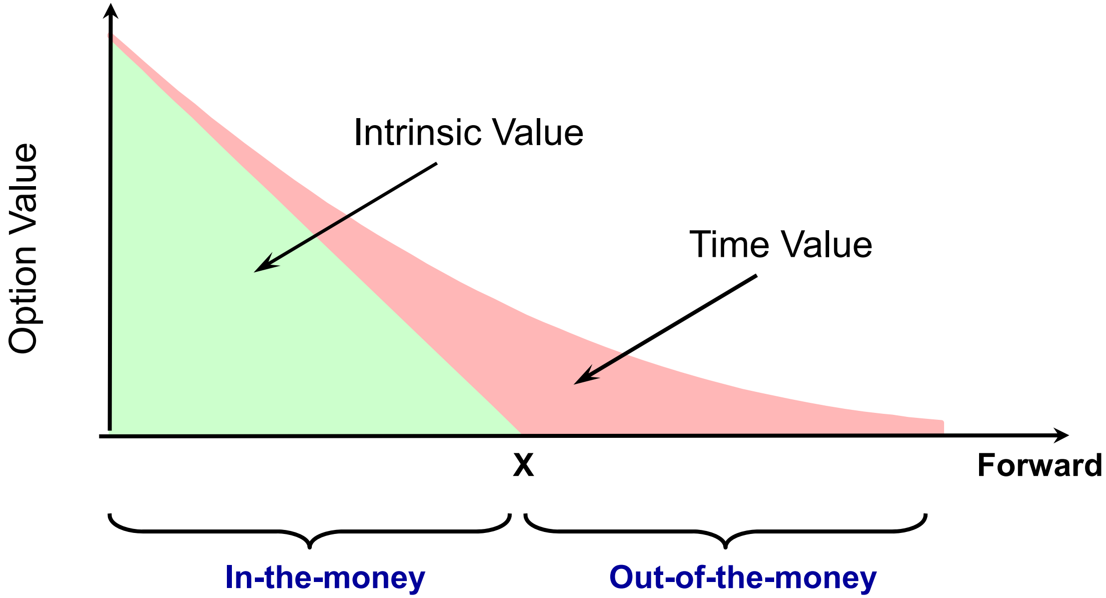
For a Call …

- **if the Call is Out-of-the-money (Forward less than Strike) there is only Time Value (Intrinsic = 0)**
- **if the Call is In-the-money (Forward greater than Strike) there is both Time Value and Intrinsic Value**

Call Price - Intrinsic Value & Time Value



Puts: Intrinsic Value and Time Value



The above graph shows the Price and Payoff for a Put with Strike X.

The Put Price is again divided into …
- Intrinsic Value
- Time Value

For a Put …

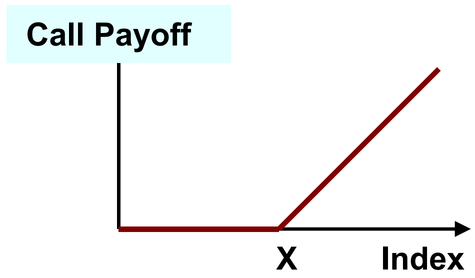
- **if the Put is Out-of-the-money (Forward greater than Strike) there is only Time Value (Intrinsic = 0)**
- **if the Put is In-the-money (Forward less than Strike) there is both Time Value and Intrinsic Value**

Black-Scholes Call Price

Suppose the distribution of an Index at time T in the future is assumed to be lognormal.

A Call on an Index with strike X, maturing at time T, is defined to have the Payoff …

Call Payoff = Max (0, Index – X)



The Black-Scholes equation states that the value of the Call is given by

$$\text{Call Price} = e^{-r(T-t)}\{F\,N(d_1) - X\,N(d_2)\}$$

where …

F = Index Fwd Rate to time T
X = Strike
σ = Volatility of the Index

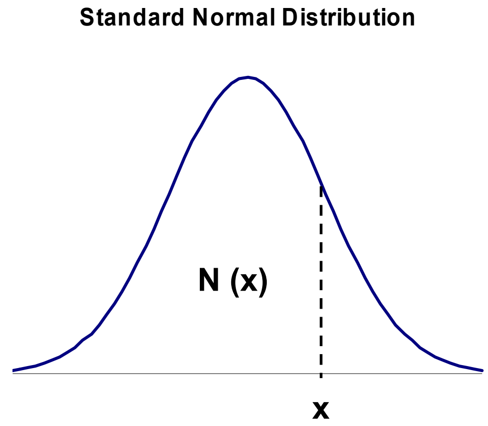
N(x) = Prob (Z<x)
Z is a N(0,1) variable
(standard Normal distribution)

$$d_1 = \frac{\ln(F/X) + (1/2)\sigma^2(T-t)}{\sigma\sqrt{(T-t)}}$$

$$d_2 = d_1 - \sigma\sqrt{(T-t)}$$

$e^{-r(T-t)}$ is the discount factor for time T

$$N(x) = \int_{-\infty}^{x} \frac{1}{\sqrt{2\pi}} e^{-(1/2)z^2}\,dz$$



Call Price – evolution over time

We graph the Call price as a function of the Forward Rate F for a selection of Terms to Maturity

Note that the graph of the Call Price approaches the payoff Max (0, Index – X) as the Term to Maturity falls. The time value falls to 0 and the Call Price converges to the Payoff (intrinsic value)

$$\text{Call Price} = e^{-r(T-t)}\{F\,N(d_1) - X\,N(d_2)\}$$

F = Index Fwd Rate to time T
X = Strike
σ = Volatility of the Index

$$d_1 = \frac{\ln(F/X) + (1/2)\sigma^2(T-t)}{\sigma\sqrt{(T-t)}}$$

$$d_2 = d_1 - \sigma\sqrt{(T-t)}$$

$e^{-r(T-t)}$ is the discount factor for time T

N(x) = Prob (Z<x)

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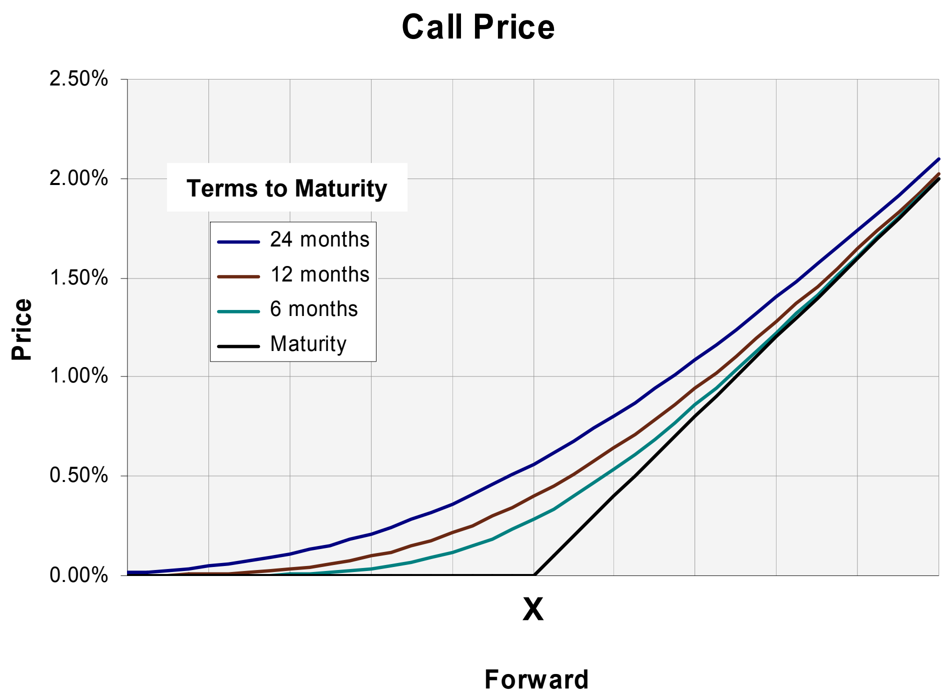
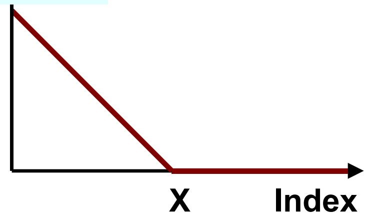


Black-Scholes Put Price

Again we suppose the distribution of an Index at time T in the future is lognormal.

A Put on an Index with strike X, maturing at time T, is defined to have the Payoff …

Call Payoff = Max (0, X – Index)



The Black-Scholes equation states that the value of the Put is given by

$$\text{Put Price} = e^{-r(T-t)}\{ X\,N(-d_2) - F\,N(-d_1) \}$$

where …

F = Index Fwd Rate to time T
X = Strike
σ = Volatility of the Index

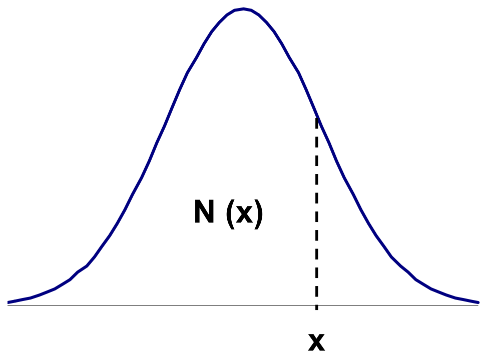
N(x) = Prob (Z<x)
Z is a N(0,1) variable
(standard Normal distribution)

$$d_1 = \frac{\ln(F/X) + (1/2)\sigma^2(T-t)}{\sigma\sqrt{(T-t)}}$$

$$d_2 = d_1 - \sigma\sqrt{(T-t)}$$

$e^{-r(T-t)}$ is the discount factor for time T

Standard Normal Distribution



Put Price – evolution over time

We also graph the Put price as a function of the Forward Rate F for a selection of Terms to Maturity

Note that the graph of the Put Price approaches the payoff Max (0, X – Index) as the Term to Maturity falls. The time value falls to 0 and the Call Price converges to the Payoff (intrinsic value)

$$\text{Put Price} = e^{-r(T-t)}\{ X\,N(-d_2) - F\,N(-d_1) \}$$

F = Index Fwd Rate to time T
X = Strike
σ = Volatility of the Index

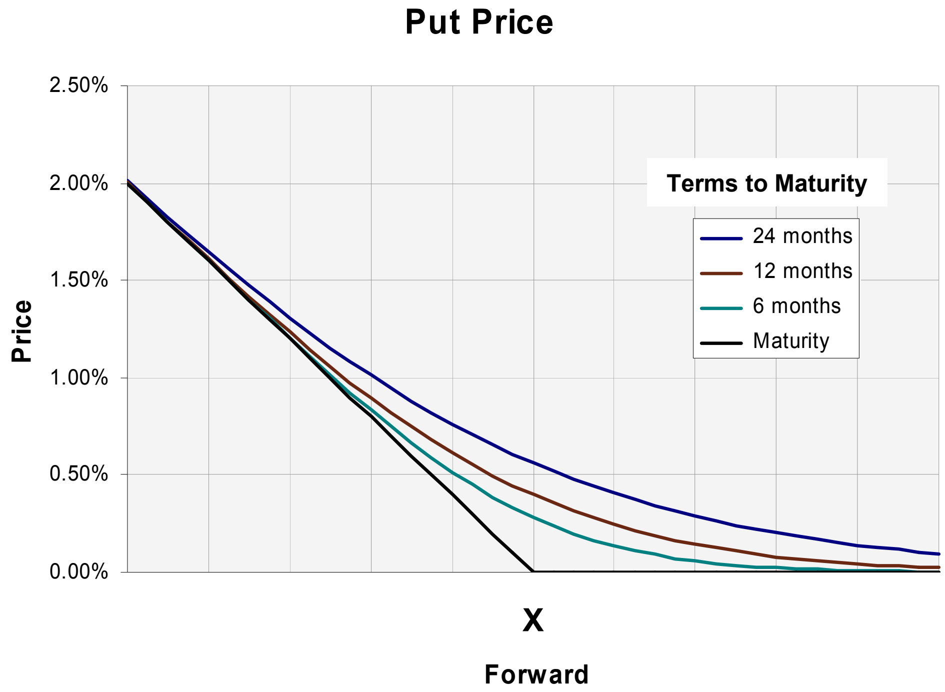
$$d_1 = \frac{\ln(F/X) + (1/2)\sigma^2(T-t)}{\sigma\sqrt{(T-t)}}$$

$$d_2 = d_1 - \sigma\sqrt{(T-t)}$$

$e^{-r(T-t)}$ is the discount factor for time T

N(x) = Prob (Z<x)

Z is a N(0,1) variable
(standard Normal distribution)



Put - Call Parity

Put - Call Parity for European options implies that for identical Calls and Puts …

Call – Put = Long Forward

Put – Call = Short Forward

To see this we look at the Payoffs at expiry …

Call Payoff = Max (0, Index – X)

Put Payoff = Max (0, X– Index)

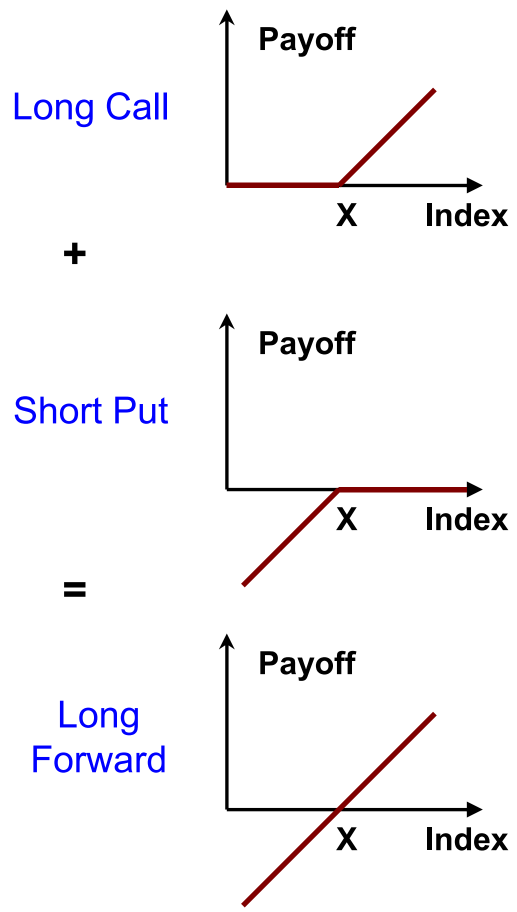
Since Max (0, Index – X) – Max (0, X – Index) = (Index – X)

it follows that …

Call Payoff – Put Payoff = Long Forward Payoff

and

Put Payoff – Call Payoff = Short Forward Payoff



Put - Call Parity

We can also check Put-Call Parity against the prices of European Calls and Puts

$$\text{Call Price} = e^{-r(T-t)}\{F\,N(d_1) - X\,N(d_2)\} \qquad (1)$$

$$\text{Put Price} = e^{-r(T-t)}\{X\,N(-d_2) - F\,N(-d_1)\} \qquad (2)$$

where …

F = Index Fwd Rate at time T
X = Strike
σ = Volatility of the swap rate

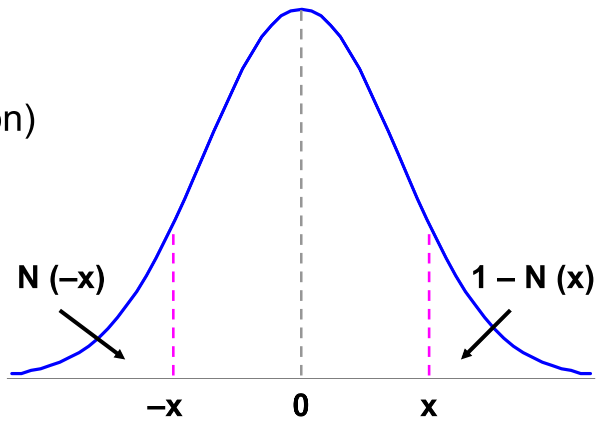
$$d_1 = \frac{\ln(F/X) + (1/2)\sigma^2(T-t)}{\sigma\sqrt{(T-t)}}$$

N(x) = Prob (Z<x)

Z is a N(0,1) variable
(standard Normal distribution)

$$d_2 = d_1 - \sigma\sqrt{(T-t)}$$

Standard Normal Distribution



Since Z is symmetric distribution around 0, we have for any x
Prob (Z< -x) = 1 – Prob (Z> -x) = 1 – Prob (Z< x)

ie N(–x) = 1 – N(x)

Then …

$$\text{Call Price} - \text{Put Price} = e^{-r(T-t)}\{[F\,N(d_1) - X\,N(d_2)] - [X\,N(-d_2) - F\,N(-d_1)]\}$$

$$= e^{-r(T-t)}\{F\,[N(d_1) + N(-d_1)] - X\,[N(d_2) + N(-d_2)]\}$$

$$= e^{-r(T-t)}\{F - X\}$$

= Price of entering a long Forward on the Index struck at X

Put - Call Parity

Similarly, (2) – (1) gives …

$$\text{Put Price} - \text{Call Price} = e^{-r(T-t)}\{X - F\}$$

= Price of entering a short Forward on the Index struck at X

Now, If the Call and Put are at-the-money (ATM), so that X = F = Index Forward Price

then Call (F) – Put (F) = Buy Index forward at F

or

$$\text{Call (F)} - \text{Put (F)} = e^{-r(T-t)}\{F - F\} = 0$$

and

Price (at the money Call) = Price (at the money Put)

Call Spread

A Call Spread is a combination of a bought Call and a sold Call at different strikes.

The Long Call is at the Low Strike, the Short Call at the High strike

$$\text{Payoff} = \text{Max}(0, I_T - X_1) - \text{Max}(0, I_T - X_2)$$

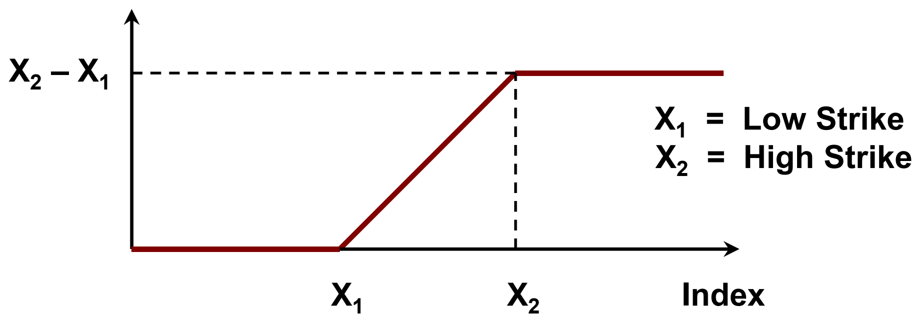
$$= \begin{cases} 0 & \text{if } I_T < X_1 < X_2 \\ (I_T - X_1) & \text{if } X_1 < I_T < X_2 \\ (X_2 - X_1) & \text{if } X_1 < X_2 < I_T \end{cases}$$

where …

I_T = Index fixing at Maturity (time T)

X_1 = Low Strike

X_2 = High Strike



Put Spread

A Put spread is a combination of a bought Put and a sold Put at different strikes.

The Long Put is at the High Strike, the Short Put at the Low strike

$$\text{Payoff} = \text{Max}(0, X_2 - I_T) - \text{Max}(0, X_1 - I_T)$$

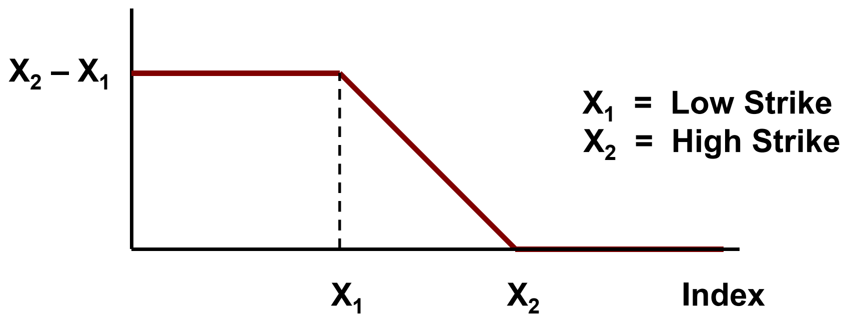
$$= \begin{cases} (X_2 - X_1) \times \text{DayCount} & \text{if } L < X_1 < X_2 \\ (X_2 - L) \times \text{DayCount} & \text{if } X_1 < L < X_2 \\ 0 & \text{if } X_1 < X_2 < L \end{cases}$$

where …

I_T = Index fixing at Maturity (time T)

X_1 = Low Strike

X_2 = High Strike



Caps

A Cap is a basic Call on a floating Index, for example Libor or Euribor.

They frequently occur in structures where coupons dependent on a floating Index are either …

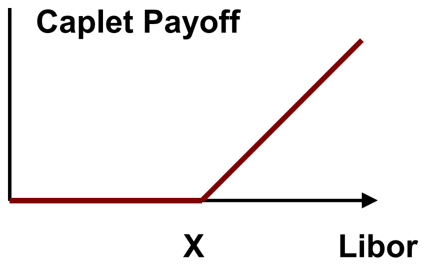
- capped by a maximum (a coupon cap)
- floored by a minimum (a coupon floor)

The Cap payoff, which is typically paid at the end of the coupon period to which it applies, is defined as …

$$\text{Cap Payoff} = \text{Max}(0, L - X) \times \text{DayCount} = \begin{cases} (L - X) \times \text{DayCount} & \text{if } L > X \\ 0 & \text{otherwise} \end{cases}$$

where …

L = Libor fixing
X = Strike
DayCount = day count of the underlying period.



In practice, we usually call this option a Caplet, reserving the term Cap for a series of consecutive caplets.

For example, a 5yr Cap might be defined as the series of 10 semi-annual caplets. This is a series of calls on the Index, each with a common strike.

Caplets

The Payoff in a Caplet usually occurs at the end of the underlying period. This helps ensure that the caplet acts in harmony with floating rate coupons to "cap" the coupon.

For example, suppose we have a floating rate Note bearing a coupon of
3m USD Libor + 0.50% paid in arrears

If we impose the condition that the maximum coupon permitted in a period is 6.00%, then we have implicitly added a caplet struck at 5.50% to the coupon.

Then the coupon can be decomposed as ..

Min (3m USD Libor + 0.50%, 6.00%) = (3m USD Libor + 0.50%) + Min (0, 5.50% – 3m USD Libor)
= (3m USD Libor + 0.50%) - Max (0, 3m USD Libor – 5.50%)

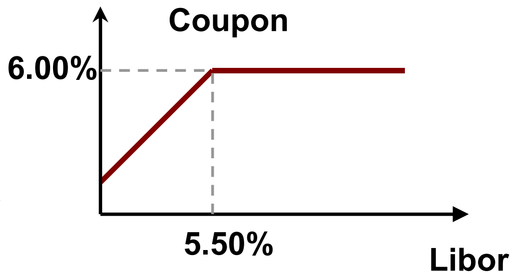
Long a floating coupon (first term) | Short a Caplet struck at 5.50% (second term)

Then the Coupon payment at the end of a 91 day period is ..

if Libor <= 5.50% [(3m Libor + 0.50%) x 91/360]

if Libor > 5.50% [(3m Libor + 0.50%) x 91/360]
– [(3m Libor – 5.50%) x 91/360] ← **Caplet payoff**

= 6.00% x 91/360

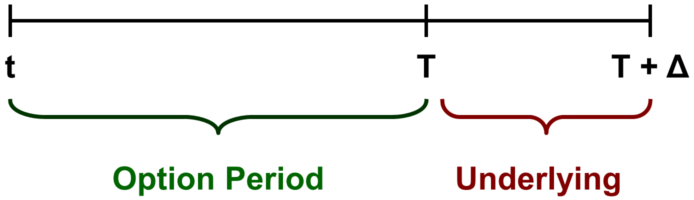


Thus the addition of a short caplet position has "capped" the coupon at 6.00%

Cap Pricing

We now look to use the Black-Scholes methodology to price a Caplet.

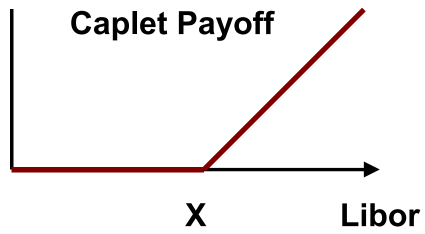
We assume a lognormal distribution for Libor, and adopt the following time-line



- Today is denoted by time t
- the caplet matures (is fixed) at time T
- the payoff of the caplet is at time T+ Δ

A caplet is a call on Libor, maturing at time T with strike X, and paid at time T+ Δ.

$$\text{Caplet Payoff} = \text{Max}(0, L - X) \times \Delta = \begin{cases} (L - X) \times \Delta & \text{if } L > X \\ 0 & \text{otherwise} \end{cases}$$



Thus the price of the caplet is given by

$$\text{Caplet Price} = \frac{\Delta}{(1 + F_T \Delta)} \times d_T \times \{ F_T \, N(d_1) - X \, N(d_2) \}$$

where …

F_T = Libor Forward Rate (T, T+Δ)

X = Strike

σ = Volatility of Libor

d_T = discount factor to time T

N(x) = Prob (Z < x), Z~ N(0,1)

$$d_1 = \frac{\ln(F_T / X) + (1/2)\sigma^2 (T - t)}{\sigma \sqrt{(T - t)}}$$

$$d_2 = d_1 - \sigma \sqrt{(T - t)}$$

$$F_T = \frac{(d_T / d_{T+\Delta} - 1)}{\Delta}$$

Floors

A Floor is similarly a basic Put on a floating Index, for example Libor or Euribor.

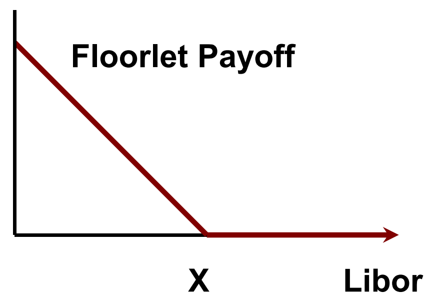
Again they frequently occur in structures where the coupons dependent on a floating Index are either capped by a maximum or floored by a minimum.

The Floor payoff, which is typically paid at the end of the coupon period to which it applies, is defined as …

$$\text{Floor Payoff} = \text{Max}(0, X - L) \times \text{DayCount} = \begin{cases} (X - L) \times \text{DayCount} & \text{if } L < X \\ 0 & \text{otherwise} \end{cases}$$

where …

L = Libor fixing
X = Strike
DayCount = day count of the underlying period.



As for caps, we often call this option a Floorlet, reserving the term Floor for a series of consecutive floorlets.

Floorlets

The Payoff in a Floorlet usually occurs at the end of the underlying period. This helps ensure that the floorlet acts in harmony with floating rate coupons to “floor” the coupon.

For example, suppose we have a floating rate Note bearing a coupon of
3m USD Libor + 0.50%   paid in arrears

If we impose the condition that the minimum coupon permitted in a period is 2.00%, then we have implicitly added a floorlet struck at 1.50% to the coupon.

Then the coupon can be decomposed as ..

Max (3m USD Libor + 0.50%, 2.00%) = (3m USD Libor + 0.50%) + Max (0, 1.50% – 3m USD Libor)

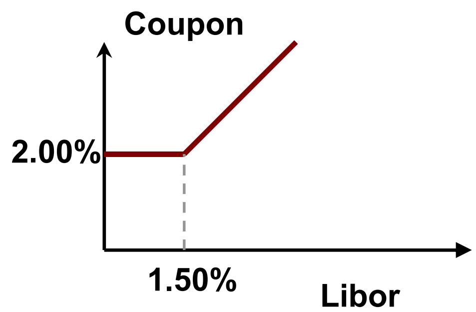
(3m USD Libor + 0.50%): Long a floating coupon
Max (0, 1.50% – 3m USD Libor): Long a Floorlet struck at 1.50%

Then the Coupon payment at the end of a 91 day period is ..

if Libor >= 1.50%   [(3m Libor + 0.50%) x 91/360]

if Libor < 1.50%   [(3m Libor + 0.50%) x 91/360]
+ [(1.50% – 3m Libor) x 91/360] ← **Floorlet payoff**

= 2.00% x 91/360

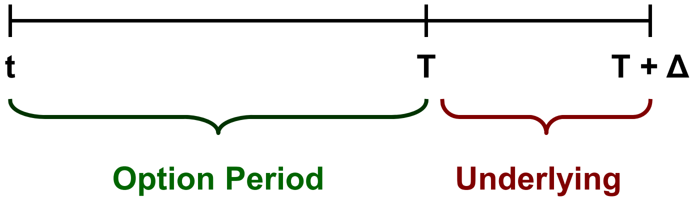


Thus the addition of a long floorlet position has “floored” the coupon at 2.00%

Floor Pricing

We now use the Black-Scholes methodology to price a Floorlet.

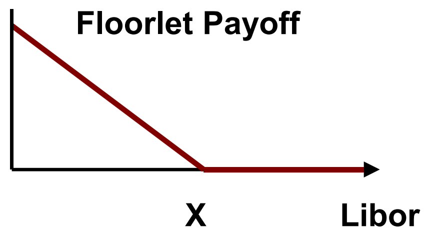
We assume a lognormal distribution for Libor, and adopt the following time-line



- Today is denoted by time t
- the floorlet matures (is fixed) at time T
- the payoff of the floorlet is at time T+ Δ

A floorlet is a put on Libor, maturing at time T with strike X, and paid at time T+ Δ.

$$\text{Floorlet Payoff} = \text{Max}(0, X - L) \times \Delta = \begin{cases} (X - L) \times \Delta & \text{if } L < X \\ 0 & \text{otherwise} \end{cases}$$



Thus the price of the floorlet is given by

$$\text{Floorlet Price} = \frac{\Delta}{(1 + F_T \Delta)} \times d_T \times \{ X\, N(-d_2) - F_T\, N(-d_1) \}$$

where …

F_T = Libor Forward Rate (T, T+Δ)

X = Strike

σ = Volatility of Libor

d_T = discount factor to time T

N(x) = Prob (Z < x), Z~ N(0,1)

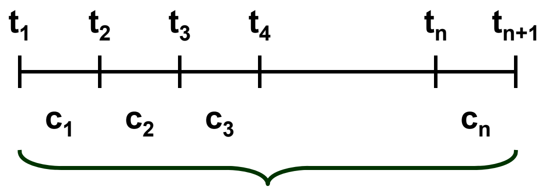
$$d_1 = \frac{\ln(F_T / X) + (1/2)\sigma^2 (T - t)}{\sigma \sqrt{(T - t)}}$$

$$d_2 = d_1 - \sigma \sqrt{(T - t)}$$

$$F_T = \frac{(d_T / d_{T+\Delta} - 1)}{\Delta}$$

Cap Vols and Caplet Vols

As mentioned, a Cap is essentially a portfolio of Caplets.
The Caplets have identical strikes and are temporally sequential, covering the life of the Cap.



Total Period of the Cap

- caplets are c_1, c_2,.., c_n
- caplet c_j is fixed at time t_j and paid at time t_{j+1}
- each caplet c_j has an individual volatility σ_j

To allow for "skew", caplet vols are functions of not just maturity but strike as well.

Each caplet c_j has an individual volatility $\sigma_j(X)$, a function of strike X.
The caplet is priced using its own vol. But we cannot observe these vols directly.

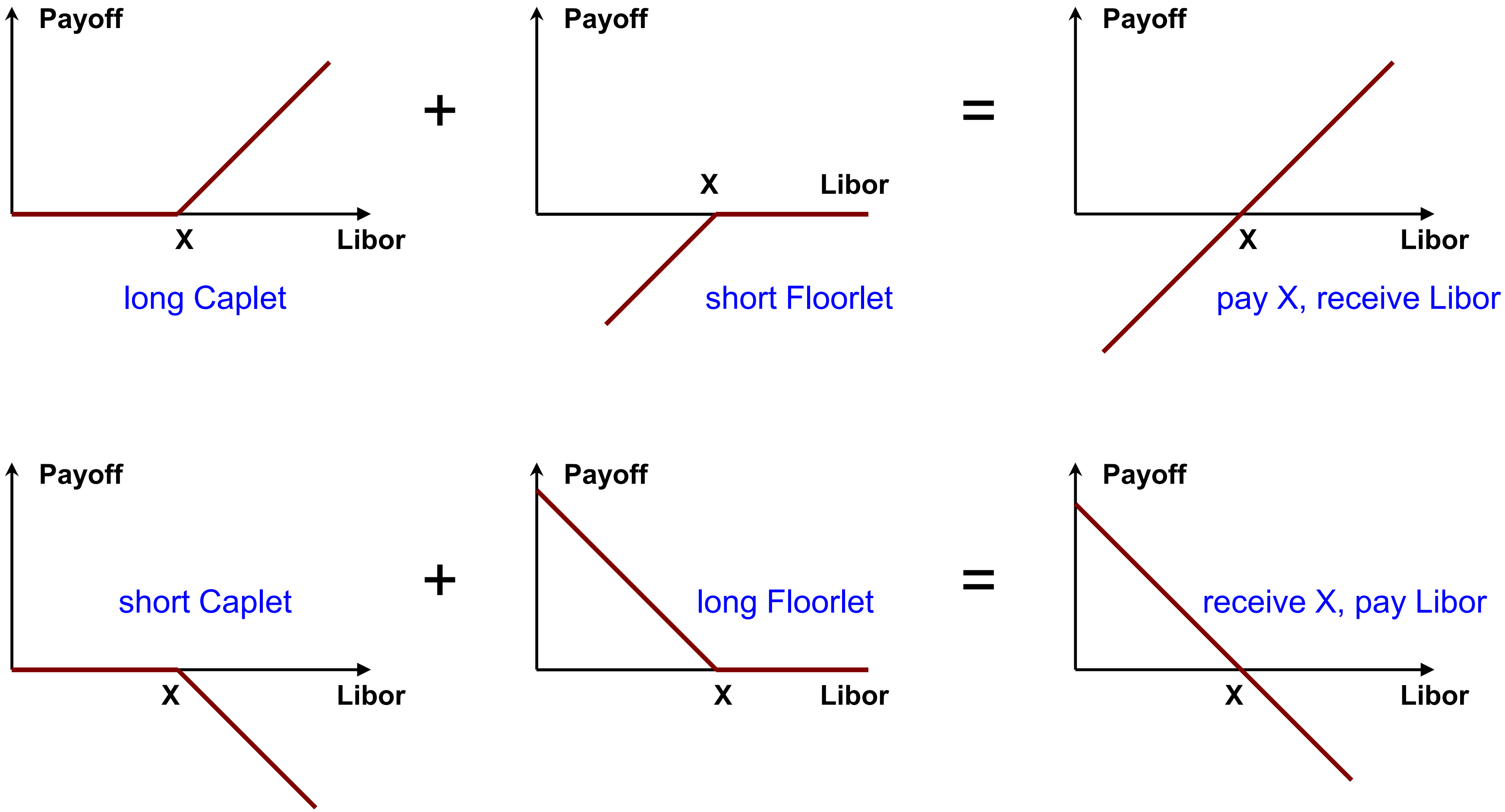
Instead, what we can observe on trader screens are Cap Vols, which are average (or flat) vols.
They are typically quoted on screens for maturities 1yr, 2yr, 3yr, … etc

If each caplet in the Cap were to be priced using the flat Cap Vol $\sigma(X)$, then the Total Cap price should match the Total Cap price obtained by pricing each caplet c_j at its individual volatility $\sigma_j(X)$

Thus by observing the flat Cap Vols $\sigma(X)$ for a series of maturities, we can use a bootstrap method to obtain caplet vols $\sigma_j(X)$ for each underlying period and strike X.

Cap & Floor Put-Call Parity

The Put-Call Parity is easy to visualize graphically ...



Appendix … Glossary of Terms

Call Option	the buyer of a Call Option has the right to buy the underlying asset on a specified date at a specified price (the strike)
Put Option	the buyer of a Put Option has the right to sell the underlying asset on a specified date at a specified price (the strike)
Strike	the price at which the asset is bought or sold if the option is exercised
Premium	the price of the Option contract the buyer of the option pays the seller of the option this price at inception
Expiry	the Maturity Date of the Option
European Option	a European Option can only be exercised on the specified Option Maturity Date
American Option	an American Option can be exercised at any time prior to the Option Maturity Date
Bermudan Option	a Bermudan Option can be exercised (once) on one of a specified set of exercise dates up to and including the Option Maturity Date These often co-incide with coupon payment dates on structured bonds and swaps

Appendix … Glossary of Terms

Option Value	the value for which the option can be bought or sold in the market At inception this is the premium paid to buy the option
Intrinsic Value	the value (if positive) of immediate exercise of the Option For a Call this is Max (0, Asset Value – Strike) For a Put this is Max (0, Strike – Asset Value)
Time Value	the residual value of the option after accounting for the Intrinsic Value It captures the potential additional payoff from the underlying moving (deeper) into the money before expiry By definition … Time Value = Option Value – Intrinsic Value
In-the-money	an option is In-the-money if the Intrinsic Value is positive
At-the-money	an option is At-the-money if the current Asset Value = Strike
Out-of-the-money	an option is Out-of-the-money if immediate exercise would result in a loss

Appendix … Glossary of Terms

European Option	a European Option can only be exercised on the specified Option Maturity Date
American Option	an American Option can be exercised at any time prior to the Option Maturity Date
Bermudan Option	a Bermudan Option can be exercised (once) on one of a specified set of exercise dates up to and including the Option Maturity Date These often co-incide with coupon payment dates on structured bonds and swaps
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Appendix … Glossary of Terms

Volatility	a measure of the variability of the price of the underlying Asset or Index In Black-Scholes, Lognormal Volatility is technically the standard deviation of the Log of the Asset Price in 1 year's time. Lognormal Vol is also effectively the standard deviation of the percentage change in the asset price over 1 year. For interest rate options, Basis Point Vol is the standard deviation of the absolute change in the interest rate Index over 1 year.
Historical Vol	the historical vol is the observed volatility of the asset price over a specified period.
Implied Vol	the implied vol is the volatility implied by the option price traded in the market. The implied vol may be higher or lower than the historical vol. Note that implied vol is in a sense forward looking, historical vol backwards looking
Delta	the sensitivity of the option price to a change in the underlying asset
Vega	the sensitivity of the option price to a change in the volatility of the underlying asset
Theta	the sensitivity of the option price to a change in the time
Gamma	the sensitivity of the Delta to a change in the underlying asset

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