# What drives option value, and put-call parity

Derivatives

## 1 A story: the bike shop offer

- Pay a small fee to lock in a buying price
- You may buy the bike later, but you need not
- Jumpy prices or more time: the offer is worth more
- The fee you pay is the option premium

IN THE LESSON

- A bike shop makes you an offer.
- Pay a small fee today, and at any time in the next three months you may buy this bike for a fixed price.
- You may, but you do not have to.
- Now ask what that offer is worth.
- If bike prices are jumping around, it is worth more, because a big jump up could save you a lot, while a jump down costs you only the fee.
- If the offer lasts a year instead of a week, it is worth more.
- If the fixed price is very low, it is worth more again.
- The fee is called the premium.
- An option is exactly this offer on a financial asset.

## 2 Calls, puts and the words around them

- Call: the right to buy at a fixed price
- Put: the right to sell at a fixed price
- Exercise price (strike) is fixed in the contract
- European: used only at expiry. Writer has the duty.

IN THE LESSON

- Let us fix the words.
- A call option gives its holder the right to buy an asset at a fixed price.
- A put option gives the right to sell at a fixed price.
- The asset is called the underlying, and here it will be a share.
- The fixed price is the exercise price, also called the strike.
- The last day is the expiry.
- We will use European options, which can be used only on the expiry day.
- The price paid for the option is the premium, or just the option price.
- The buyer has the right, and the seller, called the writer, has the obligation.
- Remember that, because the whole lesson turns on it.

## 3 Meet Harbor Foods

*Harbor Foods (made-up figures)*

| Item | Value |
|---|---|
| Share price today | $100 |
| Time to expiry | 3 months |
| Risk-free rate | 4% a year |
| Strike of main option | $100 |

IN THE LESSON

- Our running company is Harbor Foods, a made-up food maker whose shares trade at one hundred dollars.
- We will look at options that expire in three months, so a quarter of a year.
- The risk-free rate is four per cent a year.
- The risk-free rate is what a safe government loan would pay.
- We use ordinary yearly compounding, so a quarter of a year means raising one point oh four to the power of one quarter.
- We do not use continuous compounding in this lesson.
- The main option has a strike of one hundred, so it starts exactly at the money, a term we will meet properly soon.

## 4 The six drivers of an option's value

- Underlying price and exercise price: set the payoff
- Time to expiry: how long the chance lasts
- Risk-free rate: the cost of money while we wait
- Volatility: how widely the price can swing
- Income on the underlying, such as dividends

**IN THE LESSON**

- There are six inputs.
- First and second, the price of the underlying and the exercise price.
- Together they set the payoff, because a call pays the amount by which the share price beats the strike.
- Third, the time to expiry, which is how long the chance lasts.
- Fourth, the risk-free rate, because the strike is paid or received later, so the cost of money matters.
- Fifth, volatility, which measures how widely the share price swings.
- Sixth, income or costs of holding the underlying, such as dividends, which go to the share owner and not to the option holder.
- For each one we need to know which way it pushes a call and which way it pushes a put.

## 5 Three obvious drivers

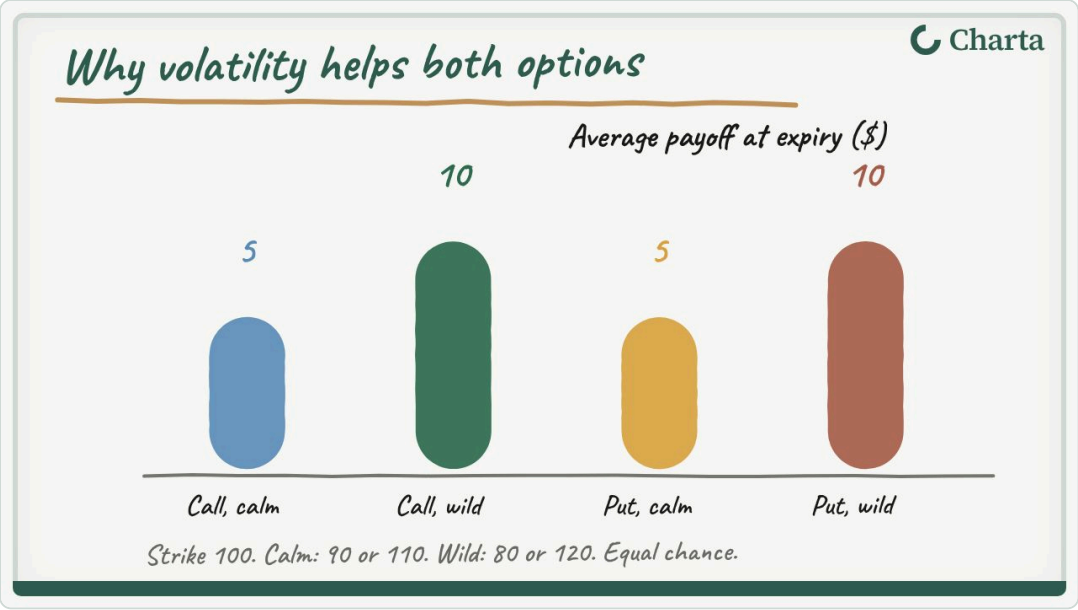
*What happens when each driver goes up*

| Driver goes up | Effect on value |
|---|---|
| Underlying price | Call up, put down |
| Exercise price | Call down, put up |
| Volatility | Both up |

**IN THE LESSON**

- Start with the three that behave as you would guess.
- A higher underlying price helps a call, because it pays when the share ends above the strike, and hurts a put, which pays when the share ends below.
- A higher exercise price is the opposite.
- A call needs the share to beat a higher hurdle, so it is worth less, while a put sells at a better price, so it is worth more.
- Volatility is the interesting one.
- A rise in volatility lifts both calls and puts.
- Do not read volatility as direction.
- It is only the width of the swings, and an option holder likes wide swings.

## 6 Why volatility helps both options




IN THE LESSON

- Here is why.
- Take a strike of one hundred and a share that ends in one of two places with equal chance.
- In the calm case it ends at ninety or one hundred and ten.
- In the wild case it ends at eighty or one hundred and twenty.
- The call pays nothing at ninety and ten at one hundred and ten, so on average it pays five.
- In the wild case it pays nothing at eighty and twenty at one hundred and twenty, so on average it pays ten.
- The put works the same way from the other side.
- It averages five in the calm case and ten in the wild case.
- The bad outcome never costs more than zero, so wider swings only add to the good outcome.
- These payoffs are before discounting, to keep the idea clear.

## 7 Three subtle drivers

*What happens when each driver goes up*

| Driver goes up | Effect on value |
|---|---|
| Time to expiry | Both up, usually |
| Risk-free rate | Call up, put down |
| Dividends | Call down, put up |

IN THE LESSON

- Now the three that catch people out.
- Time to expiry.
- More time gives the share longer to move, and for American options, which can be used any day, a longer life never hurts, so both calls and puts gain.
- For European options the usual result is the same, but there are exceptions, such as a deep in the money European put, so say usually.
- The risk-free rate.
- A higher rate lifts a call and cuts a put.
- Dividends.
- Higher expected dividends cut a call and lift a put.
- We will see why on the next slide.

## 8 Example 1: the rate and the dividend

*Strike 100 paid in one year; rate 3% then 5%; dividend of 5*

| | | |
|---|---|---|
| **Value today of strike at 3%** | 100 ÷ 1.03 | **97.09** |
| **Value today of strike at 5%** | 100 ÷ 1.05 | **95.24** |
| **Strike looks cheaper by** | 97.09 − 95.24 | **1.85** |
| **Share after a dividend of 5** | 100 − 5 | **95** |

IN THE LESSON

- Let us see the reasons with numbers.
- The strike is one hundred, paid at expiry in one year.
- At a rate of three per cent, one hundred paid later is worth one hundred divided by one point oh three today, which is ninety-seven point oh nine.
- At five per cent it is worth ninety-five point two four.
- So the higher rate makes the strike one dollar eighty-five cheaper in today's money.
- The call holder pays the strike, so the call gains.
- The put holder receives the strike, so the put loses.
- Now a dividend of five dollars paid before expiry.
- The share falls from one hundred to ninety-five, yet the option holder is not paid it.
- The call loses and the put gains.

## 9 A story: the coupon and the hope

- Coupon: buy a $100 bike for $90
- Worth at least $10 today: that part is certain
- The coupon sells for $12.06: the extra $2.06 is hope
- Option price = certain part + hope part

IN THE LESSON

- Back to the bike shop.
- A bike sells in the shop for one hundred dollars.
- You hold a coupon that lets you buy it for ninety.
- That coupon is worth at least ten dollars right now, and you can see why: use it, and you save ten.
- That part is certain.
- Now suppose someone offers you twelve dollars and six cents for the coupon.
- Why pay more than ten?
- Because the coupon has not expired.
- The bike might get dearer, and the coupon would then save even more.
- The extra two dollars and six cents is the price of that hope.
- Every option price is a certain part plus a hope part.

## 10 Intrinsic value and time value

**Call intrinsic = max(S − X, 0)**
**Put intrinsic = max(X − S, 0)**
**Option price = intrinsic + time value**

| | |
|---|---|
| **Share price, S** | What the option is written on |
| **Exercise price, X** | The fixed price in the contract |
| **Intrinsic value** | What exercising now would give |
| **Time value** | Extra paid for the chance ahead |

IN THE LESSON

- Here are the names.
- Intrinsic value is what exercising the option right now would give you, and it is never below zero.
- For a call it is the larger of the share price minus the strike, or zero.
- For a put it is the larger of the strike minus the share price, or zero.
- Time value is everything else the buyer pays: the option price minus the intrinsic value.
- It is the price of the chance that things improve before expiry.
- So the option price is simply the intrinsic value plus the time value.
- Time value is never negative for these options, because the buyer can always wait.

## 11 In, at or out of the money

*Strike 100: intrinsic value by position of the share*

| Option and share price | Intrinsic value |
|---|---|
| Call, share 110 (in the money) | 10 |
| Call, share 100 (at the money) | 0 |
| Call, share 90 (out of the money) | 0 |
| Put, share 90 (in the money) | 10 |

IN THE LESSON

- Three more words.
- An option is in the money when exercising it now would pay something, at the money when the share price equals the strike, and out of the money when exercising would pay nothing.
- Take a strike of one hundred.
- A call with the share at one hundred and ten is in the money, with intrinsic value of ten.
- With the share at one hundred, it is at the money, and with the share at ninety it is out of the money.
- Both have intrinsic value zero.
- A put is the mirror image.
- With the share at ninety, a put struck at one hundred is in the money, with intrinsic value ten.
- Notice that out of the money does not mean worthless.
- It means zero intrinsic value.

## 12 Example 2: splitting four prices

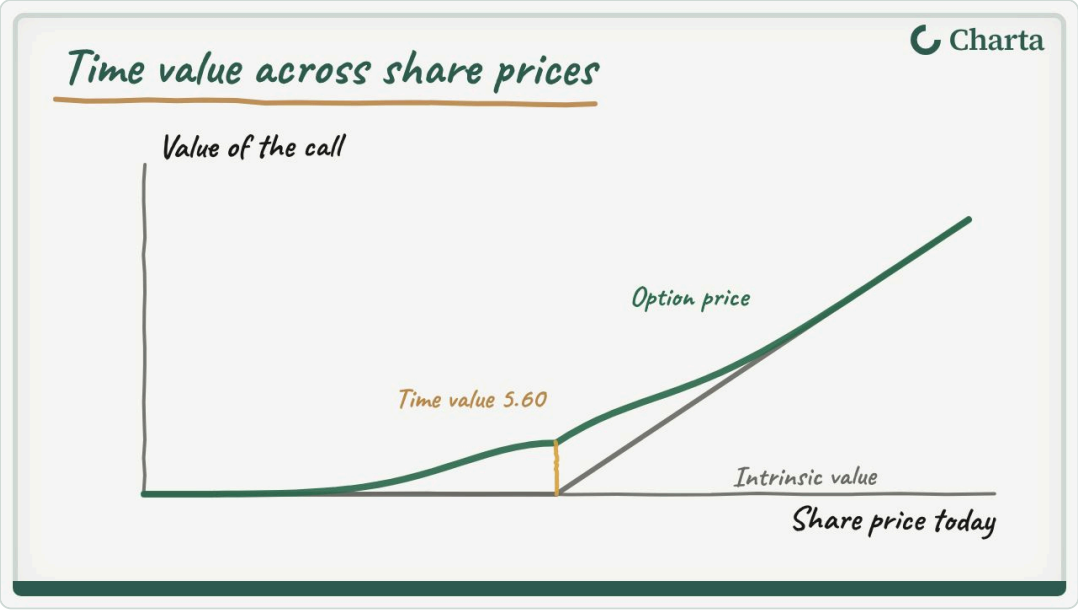
*Harbor Foods at $100, three months to expiry*

| | | |
|---|---|---|
| **Strike 90 call** | 12.06 − 10 | **time 2.06** |
| **Strike 100 call** | 5.60 − 0 | **time 5.60** |
| **Strike 110 call** | 2.06 − 0 | **time 2.06** |
| **Strike 110 put** | 10.99 − 10 | **time 0.99** |

IN THE LESSON

- Example two.
- Harbor Foods trades at one hundred, with three months to expiry.
- A call struck at ninety costs twelve dollars and six cents.
- Its intrinsic value is ten, so its time value is two dollars and six cents.
- The call struck at one hundred costs five dollars sixty.
- It is at the money, so intrinsic value is zero and the whole price is time value.
- The call struck at one hundred and ten costs two dollars and six cents, all time value.
- Now a put struck at one hundred and ten.
- By put-call parity, which we meet soon, it is worth ten dollars ninety-nine.
- Its intrinsic value is ten, so its time value is ninety-nine cents.
- The at the money option holds the most time value.

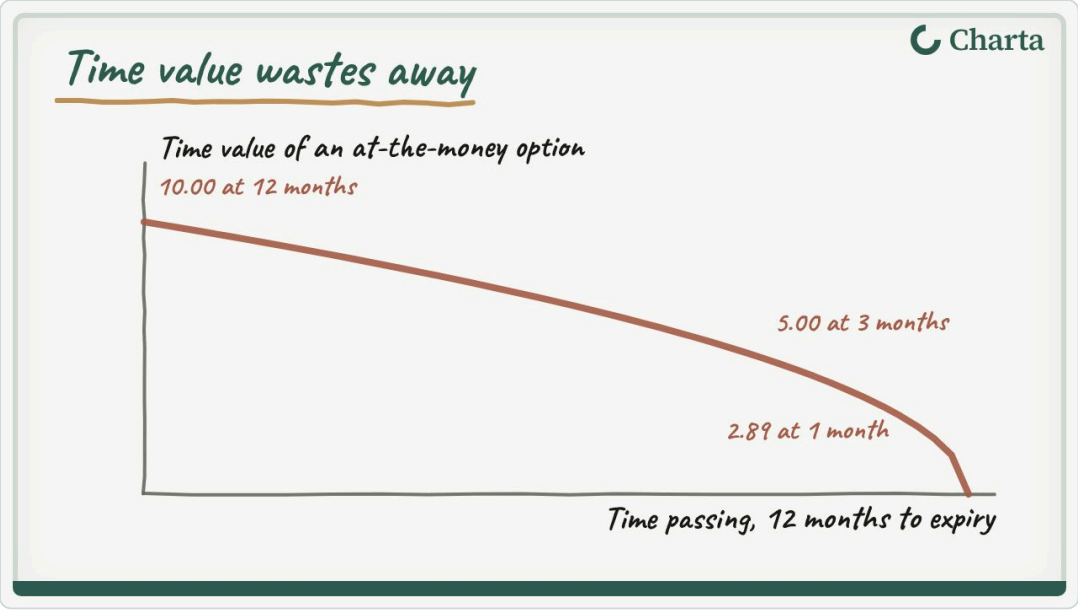
## 13 Time value across share prices




### IN THE LESSON

- Here is the picture for the call with a strike of one hundred.
- Along the bottom is the share price today, from seventy to one hundred and thirty.
- Up the side is the value of the call.
- First the grey line, the intrinsic value.
- It lies flat at zero until the strike, then climbs dollar for dollar.
- Now the green line, the option price.
- It always lies above the grey line, and the gap between them is time value.
- The gap is widest right at the strike, where it is five dollars sixty.
- It narrows on both sides, to two dollars and six cents when the share is ten dollars away.
- At the money, the outcome is hardest to predict, so the hope is worth most.

## 14 Time value wastes away




IN THE LESSON

- Now time.
- Along the bottom, time passes from twelve months before expiry on the left to expiry on the right.
- Up the side is the time value of an at the money option.
- The curve starts at ten dollars, with twelve months to go.
- It drifts down gently at first.
- After nine months it is still eight sixty-six, so only one dollar thirty-four has gone in three months.
- By three months left it is five dollars, and with one month left, two dollars eighty-nine.
- Then it falls to zero at expiry.
- So the last month alone loses two eighty-nine, more than twice what the first three months lost.
- Time value does not melt evenly.
- It speeds up near the end, which is why it is called a wasting asset.
- These numbers are an illustration of the usual shape.

## 15 Mistakes with value drivers and time value

- 1. Higher rate: call up, put down. Not both up
- 2. Intrinsic value is floored at zero
- 3. Time value peaks at the money
- 4. Time value fades faster near expiry
- 5. Volatility lifts calls and puts both

IN THE LESSON

- Five mistakes cost marks here.
- One.
- Saying a higher interest rate helps both options.
- It helps the call and hurts the put.
- Two.
- Treating intrinsic value as something that can go negative.
- It is floored at zero, so an out of the money option has zero intrinsic value, never a negative one.
- Three.
- Thinking time value is biggest for deep in the money options.
- It is biggest at the money.
- Four.
- Assuming time value fades in a straight line.
- It fades faster near expiry.
- Five.
- Reading volatility as a bet on direction.
- Higher volatility helps calls and puts alike.

## 16 A story: two ways to be safe

- Alice: owns the share, plus a put as insurance
- Bob: holds cash that grows to the strike, plus a call
- Both are protected below and gain above
- At expiry they hold the same value

IN THE LESSON

- Meet two friends who both want to profit if Harbor Foods rises, with a safety net if it falls.
- Alice owns the share and buys a put.
- If the share collapses, the put lets her sell at the strike, so she cannot lose much.
- Bob does it differently.
- He keeps cash in the bank, enough to grow to the strike by expiry, and buys a call.
- If the share soars, the call lets him buy and enjoy the gain.
- If it collapses, he simply keeps the cash and lets the call lapse.
- Their stories look different.
- But at expiry, they will be in exactly the same place.

## 17 The two portfolios

- Protective put: own the share, buy a put
- Fiduciary call: buy a call, hold a bond paying X
- The bond costs X ÷ (1 + r)^T today
- Same underlying, strike and expiry; European

IN THE LESSON

- Give the two friends their proper names.
- Alice holds a protective put: a share plus a put.
- Bob holds a fiduciary call: a call plus a risk-free bond that pays the exercise price at expiry.
- The bond costs the present value of the exercise price today, which is the exercise price divided by one plus the rate, raised to the time to expiry.
- Both packages involve the same European options, with the same underlying, the same strike and the same expiry.
- That condition matters.
- If the strikes or dates differ, the two packages are no longer the same.

## 18 Same value at expiry, either way

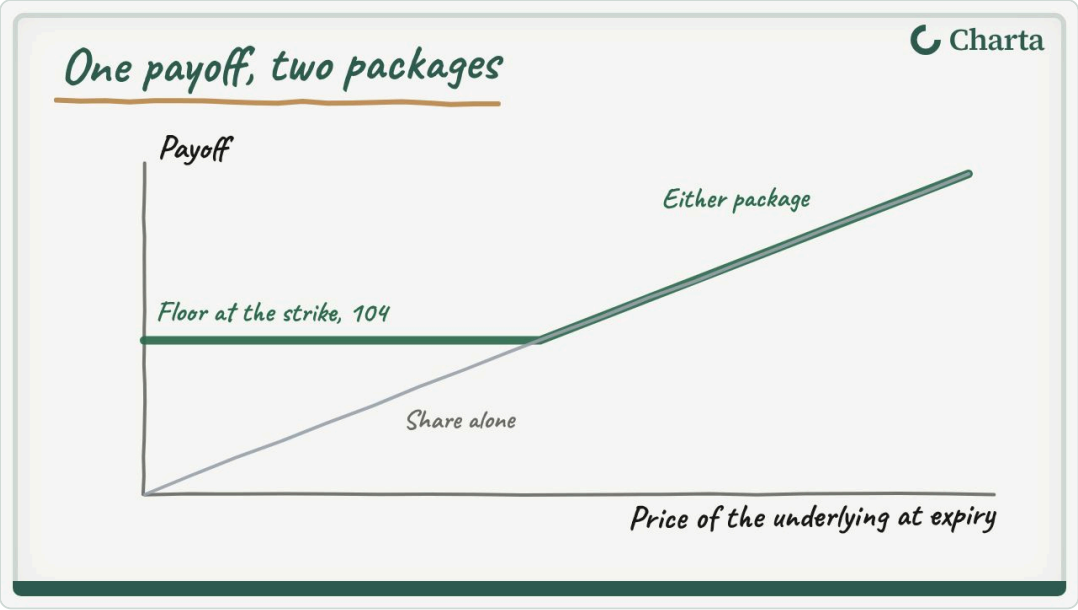
*Value of each package at expiry*

| Package and case | Value at expiry |
|---|---|
| Call + bond, share ends above X | S |
| Put + share, share ends above X | S |
| Call + bond, share ends below X | X |
| Put + share, share ends below X | X |

IN THE LESSON

- Check each case at expiry.
- First suppose the share ends above the strike.
- Bob's call pays the share price minus the strike, and his bond pays the strike, so he holds the share price.
- Alice's put is worthless, and her share is worth the share price.
- Same.
- Now suppose the share ends below the strike.
- Bob's call is worthless, and his bond pays the strike, so he holds the strike.
- Alice's put pays the strike minus the share price, and her share is worth the share price, so she also holds the strike.
- Same again.
- In every case the two values match, and no probabilities were needed.

## 19 One payoff, two packages




IN THE LESSON

- Here is the same fact as a picture.
- Along the bottom is the price of the underlying at expiry.
- Up the side is the payoff of the package.
- First the thin grey line: the share alone, rising dollar for dollar.
- Now the thick green line, which is either package.
- With a strike of one hundred and four, it lies flat at one hundred and four whenever the share ends below the strike.
- That is the floor, the strike, delivered by the put or by the bond.
- Above the strike it rises with the share, dollar for dollar, because the call pays the gain.
- One line, two ways to build it.
- Packages with the same payoff in every case must cost the same today.

## 20 Put-call parity

**c + X ÷ (1 + r)^T = p + S**

| | |
|---|---|
| **Call price, c** | Call: right to buy at X |
| **PV of strike** | Strike discounted to today |
| **Put price, p** | Put: right to sell at X |
| **Share price today** | Underlying price now |

IN THE LESSON

- So the two packages must cost the same today.
- That statement is put-call parity.
- The call price plus the present value of the exercise price equals the put price plus the share price.
- Read it as bond plus call on the left, and share plus put on the right.
- It does not need a model of volatility or any view on the share.
- If the prices ever disagree, someone can lock in a riskless profit.
- That is why it is called a no-arbitrage rule.
- It holds for European options on an underlying with no income.
- Learn it, and learn to rearrange it, because questions give you any three of the four prices and ask for the fourth.

## 21 Example 3: finding the put

*Share 103, strike 104, one year, rate 4%, call 9*

| | | |
|---|---|---|
| **Present value of strike** | 104 ÷ 1.04 | **100.00** |
| **Call plus bond** | 9 + 100 | **109** |
| **Put = 109 − share** | 109 − 103 | **6** |
| **Check: put plus share** | 6 + 103 | **109** |

IN THE LESSON

- Example three.
- Harbor Foods has moved up to one hundred and three.
- A one-year call with a strike of one hundred and four costs nine dollars, and the rate is four per cent.
- What should the put with the same strike and expiry cost?
- First discount the strike.
- One hundred and four divided by one point oh four is exactly one hundred.
- Add the call price of nine, and the package is worth one hundred and nine.
- The put plus the share must also be one hundred and nine, so the put is one hundred and nine minus one hundred and three, which is six dollars.
- Check it.
- Six plus one hundred and three is one hundred and nine.
- The trap is to use the strike of one hundred and four undiscounted.

## 22 Rearranging: build one from the rest

- Synthetic call = put + share − borrowing
- Synthetic put = call + lending − share
- Synthetic share = call − put + lending
- Synthetic bond = put + share − call

IN THE LESSON

- Because the identity links four things, you can build any one of them from the other three.
- Move terms around.
- A call equals a put plus the share minus the bond.
- In practice that means buy the put and the share, and borrow the present value of the strike.
- A put equals a call plus the bond minus the share: buy the call, lend the present value of the strike, and sell the share short.
- A share equals a call minus a put plus the bond.
- And a bond equals a put plus the share minus the call.
- These built versions are called synthetic.
- Their payoffs match the real thing at expiry, so they must cost the same.

## 23 Example 4: building synthetics

*Put 6, share 103, call 9, strike's present value 100*

| | | |
|---|---|---|
| **Synthetic call** | 6 + 103 − 100 | **9** |
| **Synthetic put** | 9 + 100 − 103 | **6** |
| **Synthetic share** | 9 − 6 + 100 | **103** |
| **Synthetic bond** | 6 + 103 − 9 | **100** |

IN THE LESSON

- Example four, with the same prices: the put is six, the share one hundred and three, the call nine, and the bond one hundred.
- To build a call, take the put, add the share, and subtract the bond, meaning borrow one hundred.
- Six plus one hundred and three minus one hundred is nine, the call price.
- To build a put, take the call, add the bond, and subtract the share.
- Nine plus one hundred minus one hundred and three is six.
- To build the share, take the call, subtract the put, and add the bond.
- Nine minus six plus one hundred is one hundred and three.
- Last, the bond is six plus one hundred and three minus nine, which is one hundred.

## 24 Example 5: an arbitrage

*Call quoted at 10, not 9. Put 6, share 103, borrow at 4%*

| | | |
|---|---|---|
| **Sell the call** | collect | **+10** |
| **Buy put and share** | 6 + 103 | **−109** |
| **Borrow PV of strike** | repay 104 at expiry | **+100** |
| **Cash today** | 10 − 109 + 100 | **+1** |

*At expiry the legs cancel exactly. The $1 is riskless.*

IN THE LESSON

- Example five.
- Suppose the call is quoted at ten dollars, not nine, while the put is six, the share one hundred and three, and the present value of the strike one hundred.
- Then the call package costs one hundred and ten, but the put package costs only one hundred and nine.
- The call side is dear.
- So sell the call and collect ten.
- Buy the put and the share, paying one hundred and nine.
- Borrow the present value of the strike, one hundred.
- Cash today is ten minus one hundred and nine plus one hundred, a profit of one dollar.
- At expiry you repay one hundred and four, and whatever the share does, the legs cancel exactly.
- The one dollar is yours with no risk.

## 25 Example 6: parity with a dividend

*Dividend of 2 in six months; put 6, share 103, strike 104, rate 4%*

| | | |
|---|---|---|
| **Value today of the dividend** | 2 ÷ 1.04^0.5 | **1.96** |
| **Share price less dividend** | 103 − 1.96 | **101.04** |
| **Call = put + share − PV of X** | 6 + 101.04 − 100 | **7.04** |
| **Call without a dividend** | earlier example | **9.00** |

IN THE LESSON

- One more case, a share that pays a dividend.
- Suppose Harbor Foods will pay a dividend of two dollars in six months.
- A share owner receives it, but an option holder does not.
- So we must take the present value of the dividend off the share price.
- Discounting two dollars for half a year at four per cent gives one dollar ninety-six.
- The adjusted share price is one hundred and three minus one ninety-six, which is one hundred and one oh four.
- Keep the put at six and the strike's present value at one hundred.
- The call is six plus one hundred and one oh four minus one hundred, which is seven dollars and four cents.
- That is below the nine dollars we had before.
- Dividends cut calls, as promised.

## 26 A story: the price lock on a delivery

- Forward: agree a price today, trade later
- Costs nothing to enter at the fair forward price
- No income: forward price F = S × (1 + r)^T
- Can a forward replace the share in parity? Yes

IN THE LESSON

- Now a cousin of the idea.
- Suppose a restaurant agrees today to buy a crate of Harbor Foods products in a year, at a price fixed now, with nothing paid until delivery.
- That agreement is a forward contract.
- The agreed price is called the forward price, and it is set so the agreement is worth nothing to either side at the start.
- For a share with no income, the forward price is the share price grown at the risk-free rate.
- A later lesson shows why.
- Here we simply use it.
- The question is whether we can swap the share in put-call parity for a forward, and the answer is yes.

## 27 Put-call-forward parity

**c + X ÷ (1 + r)^T = p + F ÷ (1 + r)^T**

| | |
|---|---|
| **Call price, c** | Call: right to buy at X |
| **PV of strike** | Strike discounted to today |
| **Put price, p** | Put: right to sell at X |
| **PV of forward price** | Forward price discounted |

IN THE LESSON

- Here is the version with a forward.
- The call price plus the present value of the exercise price equals the put price plus the present value of the forward price.
- Compare it with the earlier rule.
- The only change is on the right-hand side: the share has been replaced by the present value of the forward price.
- Why is that allowed?
- Because buying the forward and lending the present value of its price gives you the share at expiry, with the share price and the present value of the forward price equal today when there is no income.
- It is the same no-arbitrage statement, in instruments that may be easier to trade.

## 28 Example 7: testing the forward version

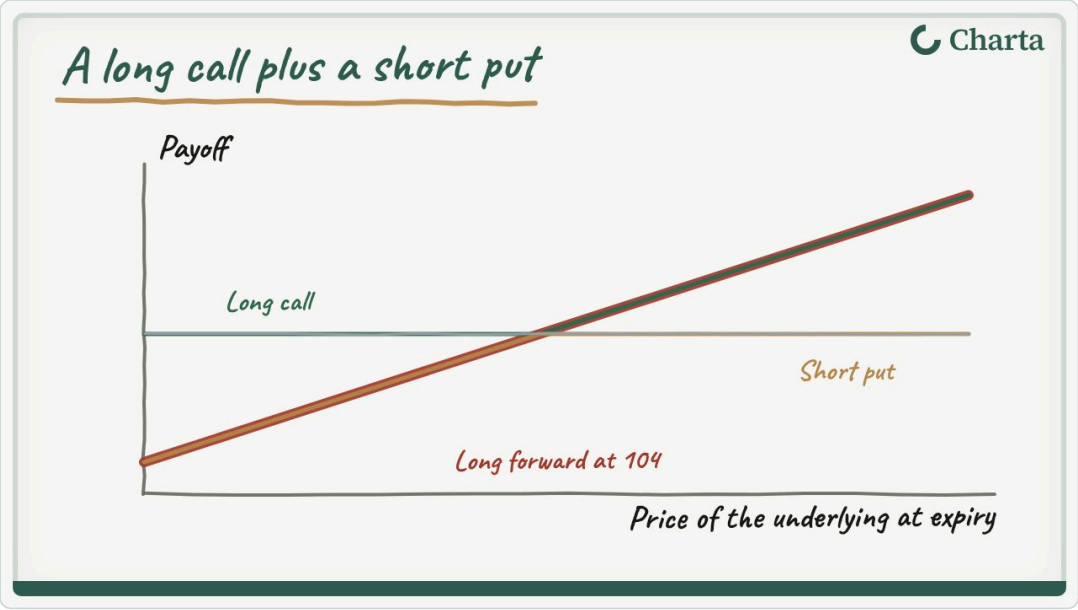
*Share 103, one year, rate 4%, strike 104, call 9, put 6*

| | | |
|---|---|---|
| **Forward price** | 103 × 1.04 | **107.12** |
| **Present value of forward price** | 107.12 ÷ 1.04 | **103.00** |
| **Call side** | 9 + 100 | **109** |
| **Put side** | 6 + 103 | **109** |

IN THE LESSON

- Example seven, with the same options.
- The share is one hundred and three and the rate four per cent for one year.
- The fair forward price is one hundred and three times one point oh four, which is one hundred and seven twelve.
- Its present value is that figure divided by one point oh four, which is one hundred and three.
- Call plus strike value is nine plus one hundred, or one hundred and nine.
- Put plus forward value is six plus one hundred and three, also one hundred and nine.
- They match, as they should.
- A trap to avoid: use the present value of the forward price, not the forward price itself, and not the strike on both sides unless the strike equals the forward price.

## 29 A long call plus a short put




IN THE LESSON

- Rearrange the forward version and you can build a forward from options.
- Buy a call and write a put at the same strike and expiry.
- Here is the payoff.
- Along the bottom is the price of the underlying at expiry, and up the side is the payoff.
- The strike is one hundred and four, where the zero line sits.
- The green line is the long call: nothing below the strike, a gain above it.
- The gold line is the short put: a loss below the strike, nothing above it.
- Add them, and you get the thick red line, one straight line through the strike.
- That is a long forward bought at one hundred and four.
- Someone always exercises, so it is an obligation, not a choice.

## 30 Example 8: the synthetic forward

*Long call and short put at strike 104; call 9, put 6; forward 107.12*

| | | |
|---|---|---|
| **Cost today of call minus put** | 9 − 6 | **3.00** |
| **Forward worth at 104** | (107.12 − 104) ÷ 1.04 | **3.00** |
| **Effective price for the share** | 3 × 1.04 + 104 | **107.12** |
| **If strike is 107.12** | c − p = 0 | **call = put** |

IN THE LESSON

- Example eight, the numbers behind the picture.
- Buying the call and writing the put costs nine minus six, three dollars today.
- A real forward at a price of one hundred and four would be worth the present value of the gap between the fair forward price and the agreed price.
- That is one hundred and seven twelve minus one hundred and four, three twelve, divided by one point oh four, which is three dollars.
- The two match.
- Put another way, you pay three dollars now and one hundred and four at expiry.
- The three dollars grows to three twelve, and the total is one hundred and seven twelve, the forward price.
- And if the strike equals the forward price, the call and the put cost the same.

## 31 Example 9: a forward arbitrage

*Forward quoted 108, not 107.12. Call 9, put 6, strike 104*

| | | |
|---|---|---|
| **Buy call, sell put** | 9 − 6 | **−3.00** |
| **Sell forward at 108** | costs nothing | **0** |
| **Locked in at expiry** | 108 − 104 | **+4.00** |
| **Value today of that** | 4 ÷ 1.04 | **3.85** |
| **Riskless gain today** | 3.85 − 3.00 | **0.85** |

IN THE LESSON

- Example nine.
- Now suppose the market quotes a forward price of one hundred and eight, not one hundred and seven twelve, while the call stays at nine and the put at six.
- Buying the call and writing the put costs three dollars.
- Selling the forward at one hundred and eight costs nothing.
- At expiry, the call and put pay the share price minus one hundred and four, and the forward pays one hundred and eight minus the share price.
- Together that is exactly four dollars, whatever happens.
- Four dollars at expiry is worth four divided by one point oh four today, which is three eighty-five.
- You paid three.
- The riskless gain today is eighty-five cents.
- Same logic as before: cheap side in, dear side out.

## 32 Mistakes with parity

- 1. Discount the strike. Do not use X itself
- 2. Same strike, same expiry, European options
- 3. Protective put = put + share. Fiduciary call = call + bond
- 4. Dividends: subtract their PV from the share price
- 5. Forward version: discount F, not S

IN THE LESSON

- Five mistakes to avoid.
- One.
- Using the exercise price instead of its present value.
- The strike is paid at expiry, so it must be discounted.
- Two.
- Applying parity to options with different strikes or expiries, or ignoring that the clean version is for European options.
- Three.
- Mixing up the packages.
- A protective put is the put plus the share, and a fiduciary call is the call plus a bond.
- Four.
- Forgetting dividends.
- Take their present value off the share price.
- Five.
- In the forward version, discounting the wrong price.
- It is the forward price that is discounted, not the share price.

## 33 Recap: the formulas to remember

**c + X ÷ (1 + r)^T = p + S**
**c + X ÷ (1 + r)^T = p + F ÷ (1 + r)^T**
**Option price = intrinsic + time value**

| | |
|---|---|
| **Call price, c** | Call price today |
| **Put price, p** | Put price today |
| **PV of strike** | Strike discounted to today |
| **Share price today** | Underlying price now |
| **PV of forward price** | Forward price discounted |

IN THE LESSON

- Let us pull it together.
- An option's price is its intrinsic value plus its time value.
- Six things drive it: the share price, the strike, the time to expiry, the risk-free rate, volatility, and income on the underlying.
- Volatility and usually time lift both calls and puts.
- A higher share price, a lower strike and a higher rate favour the call.
- Dividends and a higher strike favour the put.
- Put-call parity says the call price plus the present value of the strike equals the put price plus the share price.
- In the forward version the share price becomes the present value of the forward price.
- Rearranged, these give you every synthetic you need.

## 34 Try three quick questions

1. Call, strike 100, share 108, price 11. Intrinsic and time value?
   **Answer:** Intrinsic 8. Time value 11 − 8 = 3.
2. Share 60, call 5, present value of strike 58. Put price?
   **Answer:** Put = 5 + 58 − 60 = 3.
3. Which two changes raise a call and cut a put?
   **Answer:** A higher share price, and a higher risk-free rate.

IN THE LESSON

- Now try three quick questions yourself.
- Pause after each one.
- Question one.
- Call, strike one hundred, share one hundred and eight, price eleven.
- Intrinsic and time value?
- The answer.
- Intrinsic eight.
- Time value is eleven minus eight, which is three.
- Question two.
- Share sixty, call five, present value of strike fifty-eight.
- Put price?
- The answer.
- The put is five plus fifty-eight minus sixty, which is three.
- Question three.
- Which two changes raise a call and cut a put?
- The answer.
- A higher share price, and a higher risk-free rate.