



# Financial Markets and Institutions

**Derivatives**

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# Derivatives

- > value is determined by the value of another (underlying) financial instrument.
- > examples of derivatives are options, warrants, futures, ... currency swaps

→ Use: speculation

hedging = limit the exposure to risks.

## Future

now  
↑

Contract on spot market: transaction now, settlement now

Contract on forward market: transaction now, settlement  
later  
↓  
later

↳ you make an agreement right now, but you only get the sum later.

Future = a forward contract with market to market

$t=0$  Futures contract maturity = 3 months

Futures price = 1\$/1€ @ vs 3 months: pay €100,000

$t=1$  Futures price = 1\$/0.98€ → at maturity: pay €98,000

↳ pay €2,000 (you have to pay this to the seller of the future)

$t=2$  Futures price = 1\$/1.01€ → at maturity: pay €101,000

↳ receive €3,000 (you receive this cash from the seller)

Maturity: Pay €101,000 (+ €2,000 - 3,000 = €100,000)

## Options

Option = a right owned by someone

If, for example, you own an option to buy a house, you have the right to buy the house and no one else can buy it in the meantime

- In reality, the owner of the option will look for financing (mortgage) in the period in between.



# Definitions

Who owns an option, either has ...

- The right to buy something (= call option)
- Or the right to sell something (= put option)

An option can be on each type of asset but in most cases it is an option on stocks

To trade an option, 2 parties should be involved:

- the buyer of the option
- the initial seller = the 'writer' of the option

## Call option

The buyer of a call has

- the right
- to buy a specified number of shares
- within a certain period or  
on a specific date
- at a pre-agreed price

The seller of a call has

- the obligation
- to deliver/sell the shares to the owner of the call option if  
(s)he wishes to exercise his (her) right.

The stock on which you have the option  
= the underlying value

Number of shares: the unit of trading for an option on Euronext Derivatives is usually 100 shares

Price at which one can buy the option  
= strike price or exercise price (X)

The price of the share = S

Period in which you have the option

= maturity

Option that can be exercised within a specific time period

= American style

Option that can be exercised on a specific date

= European style

## Put option

The buyer of a put has

- the right
- to sell a specified number of shares
- within a certain period or  
on a specific date
- at a pre-agreed price

The seller of a put has

- the obligation
- to buy the shares to the owner of the put option if (s)he wishes to exercise his (her) right.

Exercising the option :

The owner of a call option will only use his right if he can buy the share cheaper, using the option, then on the market so only if strike price  $<$  market price (call)

The difference between the market price of share and the strike price is the intrinsic value of the option

The intrinsic value can never be negative since the owner of the option has a right but not an obligation

In case of a call, the intrinsic value is  $\max(0; S - X)$

In case of a put, the intrinsic value is  $\max(0; X - S)$

If the strike price equals the market price of the share, we say that the option is 'at-the-money'

If the strike price  $< (>)$  market price of the share, we say that the call (put) is 'in-the money'  $\square$  positive intrinsic value

If the option has no intrinsic value, we say it is 'out-of-the-money'



The value of an option consists of 2 parts:

- intrinsic value
  - time value
- reflects the possibility that the option will be more valuable in the future ('in-the-money') in the time remaining  
= 0 at maturity

# Graphs

Graphical presentation of the option payoff at maturity allows a better view of the option or option strategy

## Example

AB Inbev, c, maturity March 2025, strike price: € 54

Price AB Inbev: € 55,88

Price option: € 4,92

$$\begin{aligned} \text{Intrinsic value} &= \max(0; S - X) \\ &= 55.88 - 54 = 1.88 \\ \text{Time value} &= 4.92 - 1.88 = 3.04 \end{aligned}$$

# Graphs

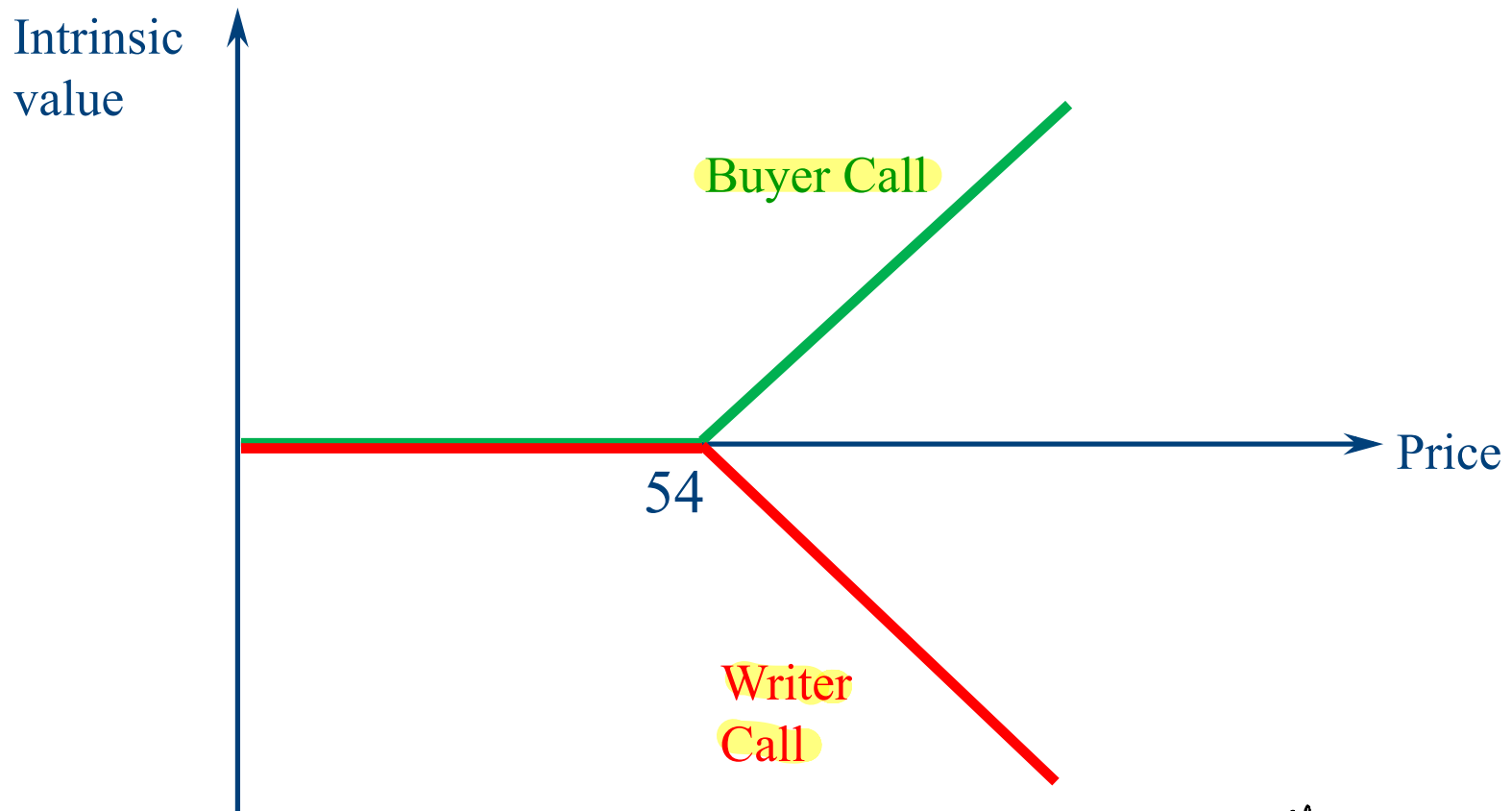
## Voorbeeld

AB Inbev, c, maturity March 2025, strike price: € 54

Price AB Inbev: € 55,88; Price option: € 4,92

	Price share	Payoff buyer call	Payoff writer call
no Buy	52,5	0	0
	53	0	0
	53,5	0	0
	54	0	0
Buy	54,5	0,5	-0,5
	55	1	-1
	55,5	1,5	-1,5
	56	2	-2

# Graph call option



Buyer call = exactly opposite to writer call.

Buyer: maximum profit is unlimited

loss is limited to the price paid for the option

Writer: maximum loss is unlimited

profit is limited to the option price received

Graph for the writer is the opposite of the graph for the buyer

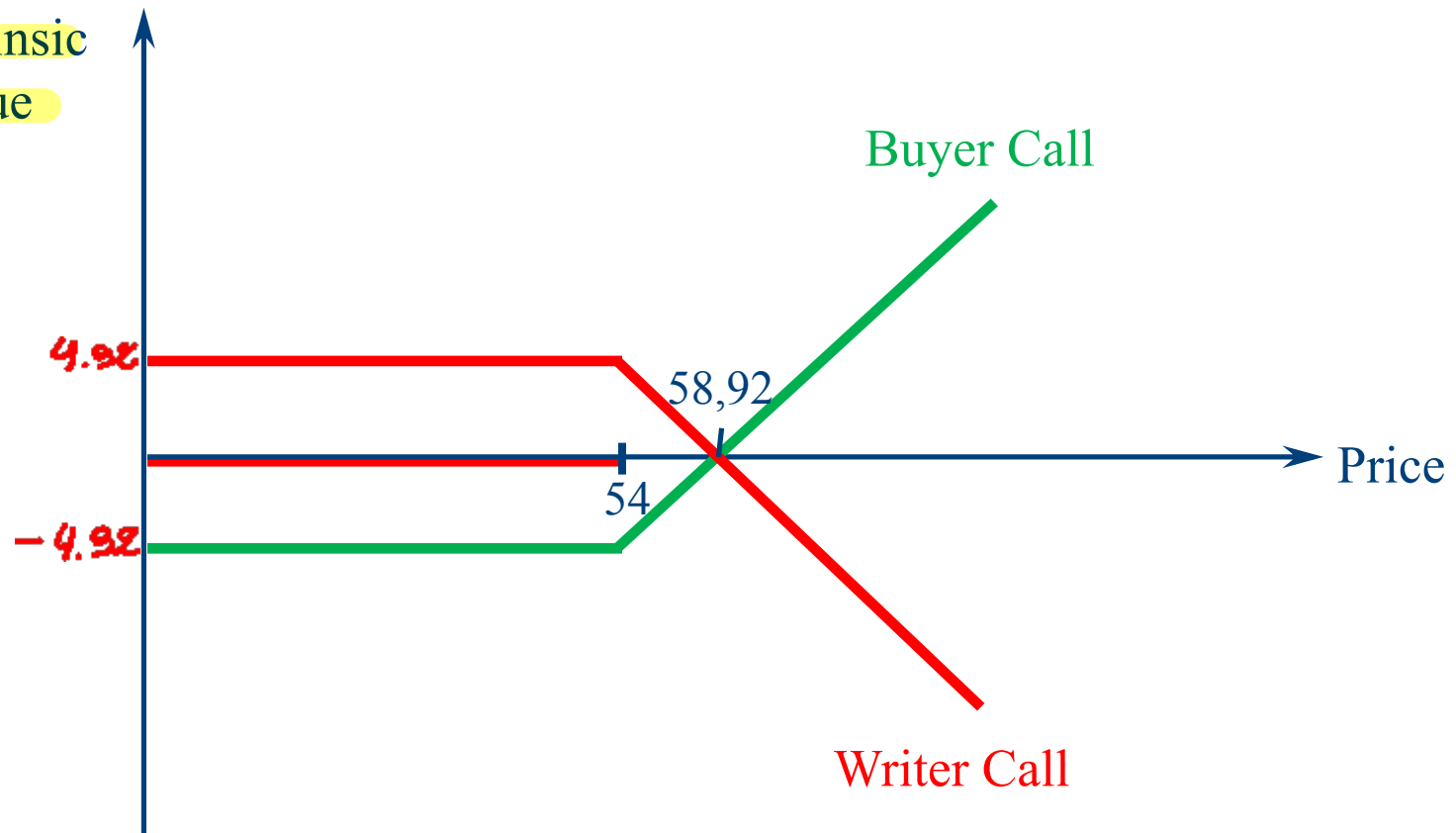
The advantage of options is the ability to achieve high returns with a limited investment

= leverage effect

Buy AB Inbev: €55.88 If stock price increases by €1  
Return =  $\frac{56.88 - 55.88}{55.88} = 0.0178 = 1.78\%$

Buy call option on AB Inbev €4.92  
Assume if stock price increases by €1, option price increases €0.5  
Return =  $\frac{5.42 - 4.92}{4.92} = 0.1016 = 10.16\%$

# Graph call option (including price of the option)



In the same way, the graph for the buyer of a put option can be made

Example:

AB Inbev p, maturity March 2025, Strike price: €60,00

Price AB Inbev: € 55,88

Price option = € 6,15

$$\begin{aligned} \text{Intrinsic value} &= \max(0, X - S) \\ &= 60 - 55.88 = 4.12 \\ \text{Time value} &= 6.15 - 4.12 = 2.03 \end{aligned}$$

# Graphs

## Example

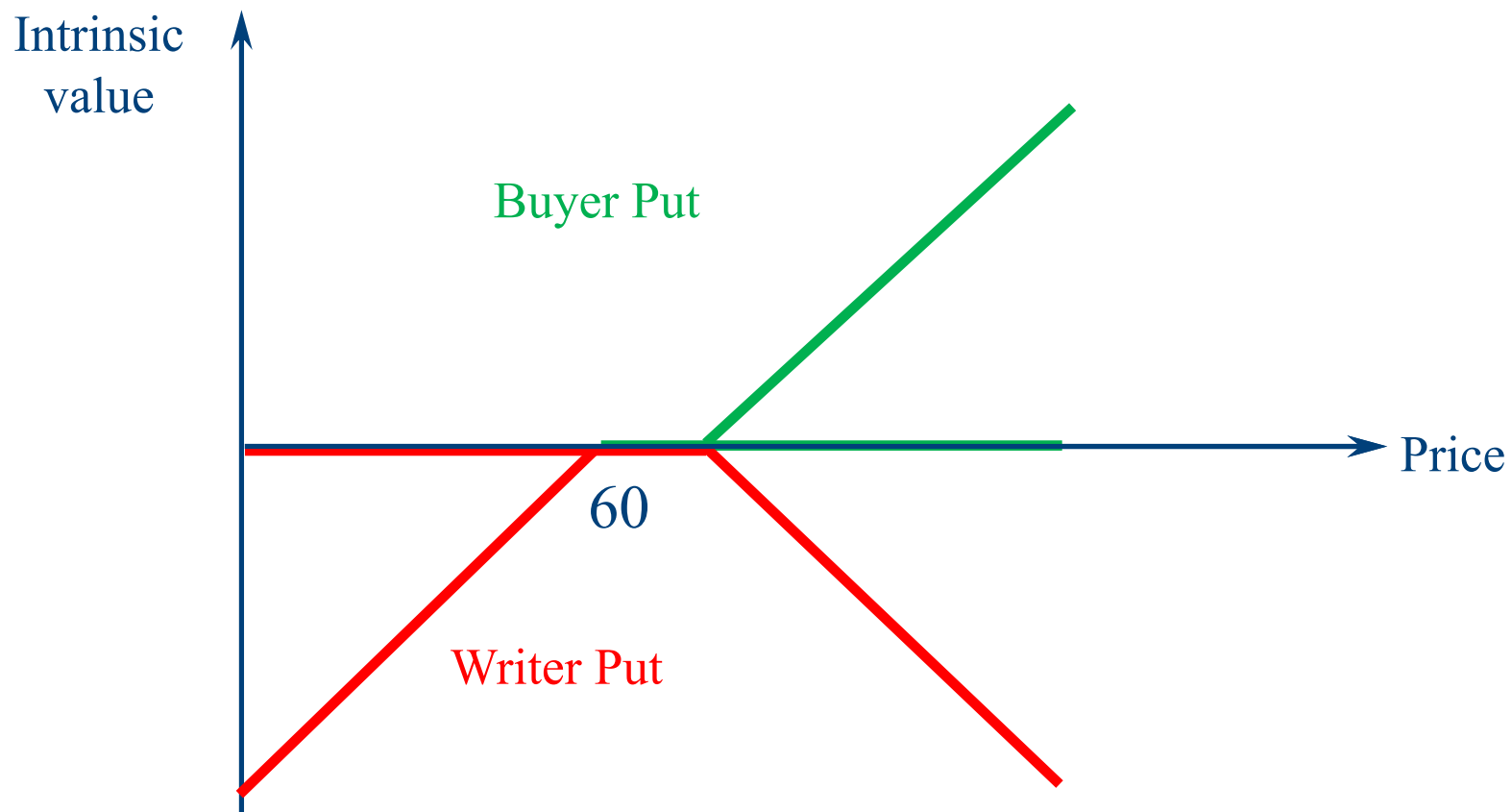
AB Inbev p, maturity March 2025, Strike price: €60,00

Price AB Inbev: € 55,88; Price option = € 6,15

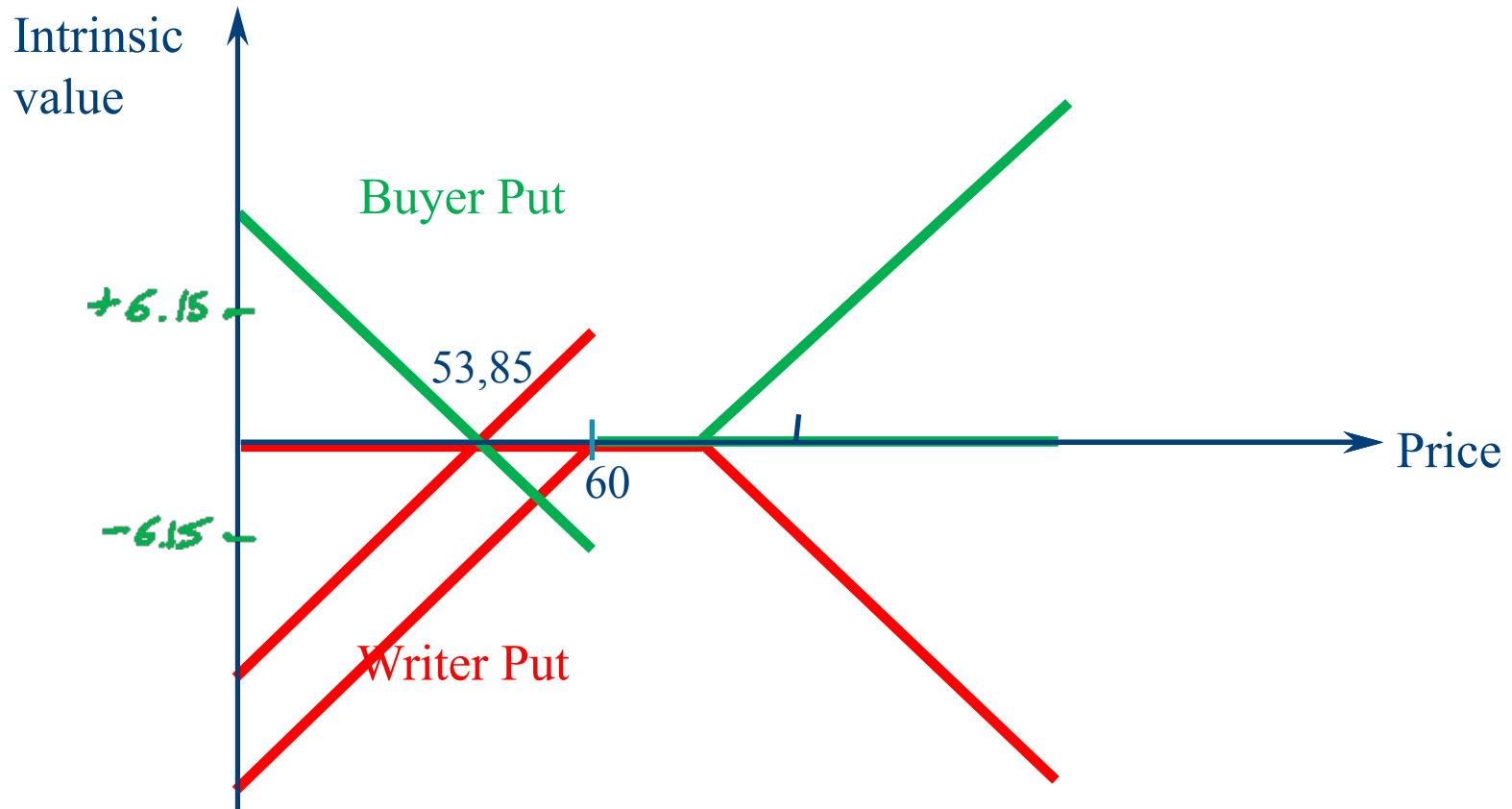
Price share	Payoff buyer put	Payoff writer put
57,5	2,5	-2,5
58	2	-2
58,5	1,5	-1,5
59	1	-1
59,5	0,5	-0,5
60	0	0
60,5	0	0
61	0	0



# Graph put option



# Graph put option (including price of the option)





# Financial Engineering

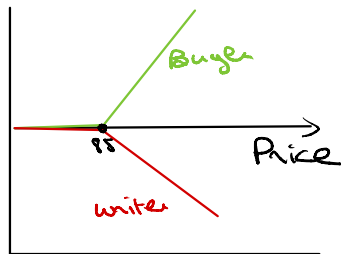
The practical use of options

# Put-Call Parity

Assume the Heineken stock trades at € 85. The investment horizon is 2 years. An investor buys a share of Heineken and a put option with strike price €85 (price €3,55).



What is the payoff at maturity of this strategy?



Put option: Buyer sells when stock price decreases

Premium Price: €3,55

After 2 years, you should only sell if stock price went down to €81,45 or lower.

# Put-Call Parity

Assume the Heineken stock trades at € 85. The investment horizon is 2 years. An investor buys a zero-bond with a maturity of 2 years (yield of 2%) and a call option with strike price €85.

→ face value of 85 €

What is the payoff at maturity of this strategy?

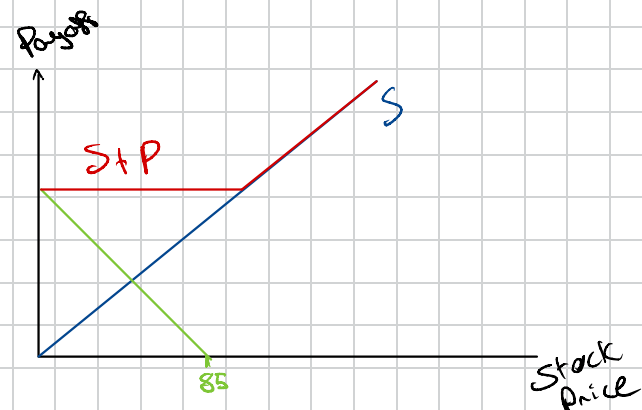
Stock		Put	=	Stock $S+P_{4x}$		zero-call	=	zero-bond		Call
83	+	2	=	85		95	=	85	+	0
84	+	1	=	85		85	=	85	+	0
85	+	0	=	85		85	=	85	+	0
86	+	0	=	86		86	=	85	+	1
87	+	0	=	87		87	=	85	+	2

$$\text{call} = S + P - \text{zero-bond}$$

$$C = 85 + 3,55 - \frac{85}{1,02^2} = 6,85$$

→ Sell = buy zero-bond + sell stock + sell Put  
 ⇒ receive 6,85

Assume price = €5 ⇒ Buy ⇒ Cost = €5  
 ⇒ profit = 1,85



# Put-Call Parity

$$\text{Share} + \text{Put} = \text{zero-bond} + \text{call}$$

What is the price of the call option?

Otherwise: arbitrage

Arbitrage: a trading strategy that involves taking advantage of price differences between markets or assets to make risk-free profit.

# Mutual fund with capital protection

- How can an investor replicate this?



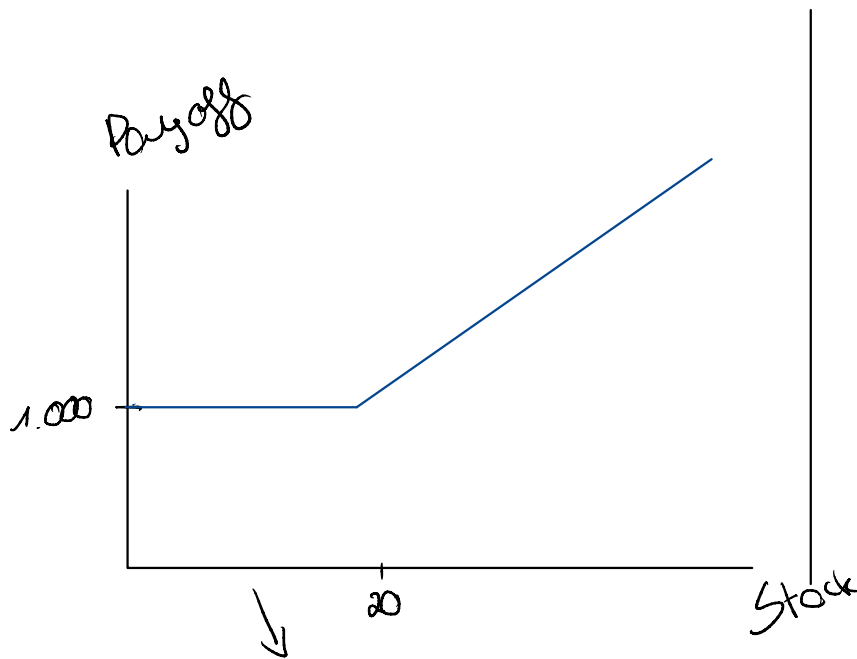
# Convertible bonds and reverse convertibles

- **Convertible bonds = bond + call**

(a bond that can be converted to a stock)

- Premium is paid in terms of a lower coupon rate

Buyer can buy stock @ strike price & sell when increase



Reverse convertible: Issuer = Bank  
Issuer has the right to pay the face value at maturity or a given amount of stock.

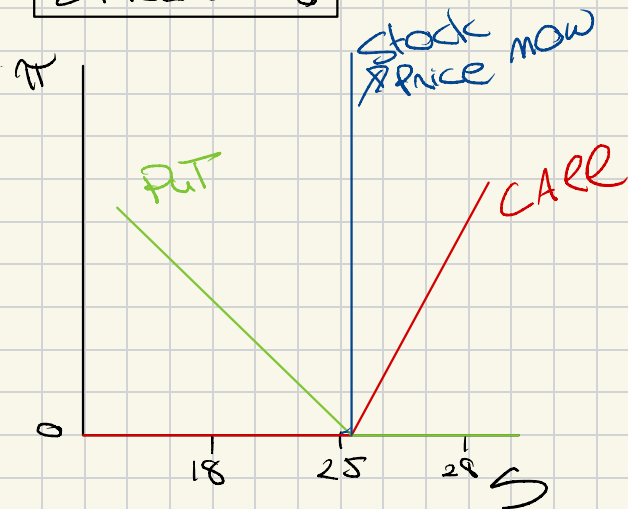
$F = 1,000$  euros in a bond for 20 euros each → conversion Rate = 50

↳ It is smart to convert the bond into stocks, if the stock is worth more than €20

# Option strategies

- **Straddle:** <sup>€25</sup> buy a call <sup>€25</sup> and put option with the same strike price
- **Long strangle:** combine a put with low strike price with a call with high strike price
- **Butterfly:** buy a call with low strike price (eg. €20), buy a call with high strike price (eg. €26) and sell 2 calls with intermediate strike price (eg. €23)

## Straddle :



when is this Straddle strategy smart?

- when you are certain the Price will move a lot, But when you don't know in what direction it will move.

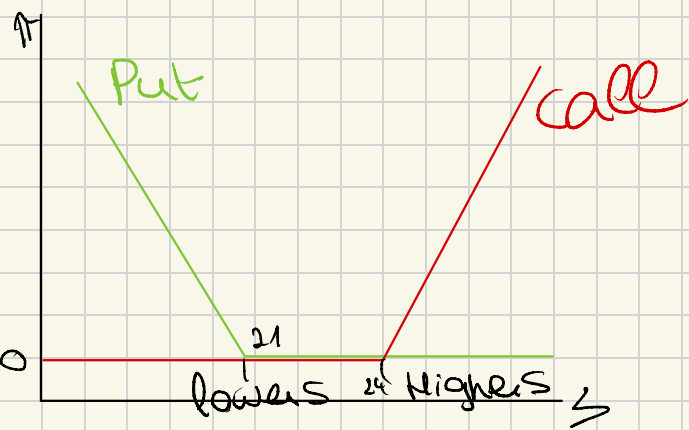
Table:

	S	C	P
20		0	+5
25		0	0
30		+5	0

Put: Sell when Price = lower than Stock Price

call: Buy when Price = Higher than Stock Price //

## Long Strangle :



when is this Long Straddle Strat. smart?

- when you are certain the Price will move a lot, But when you don't know in what direction it will move.

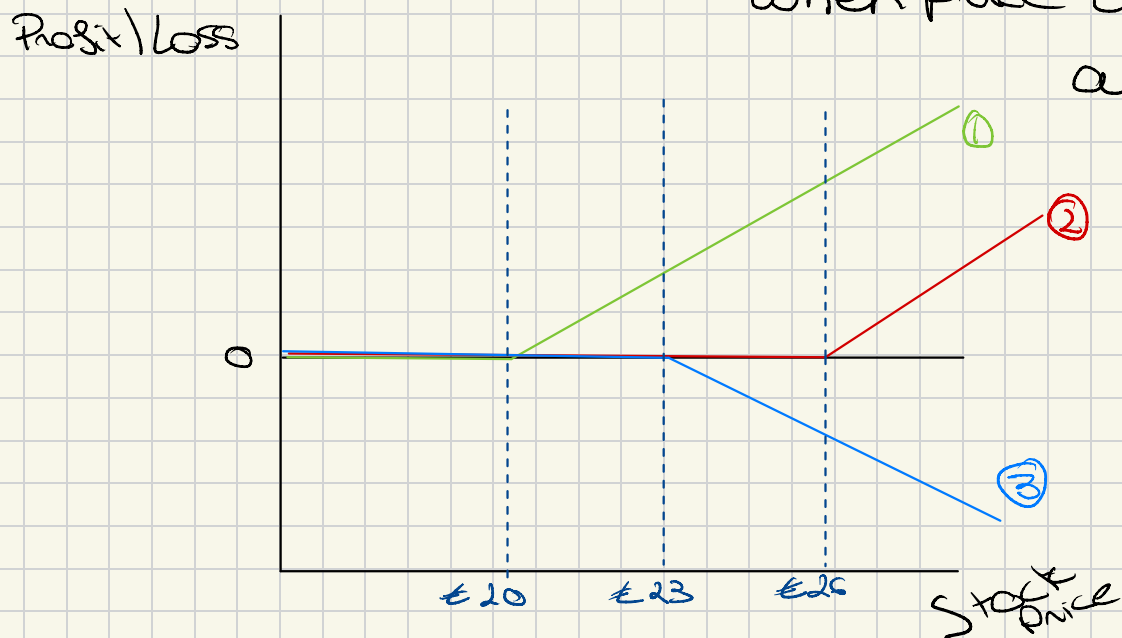
Table:

	S	C	P
20		0	+1
22		0	0
24		0	0
26		+2	0

# Butterfly %

when is this Long Straddle Strat. smart?

- when price doesn't move a lot and stays stable.



call with low strike price (Buy) (€20) ①

call with high strike price (Buy) (€26) ②

call w. intermediate S. P. (sell) x2 (€23) ③

Table %

S	LS	MS	HS
18	0	0	0
20	0	0	0
22	+2	0	0
24	+4	-1	0
26	+6	-3	0
28	+8	-5	+2

//

# Black-Scholes Option Pricing Model

- The Black-Scholes model was originally developed to price call options
- $N(d_1)$  and  $N(d_2)$  are found using the cumulative standard normal distribution tables

$C$  = call

$S$  = stock price

$E$  = Exercise (= strike price)

$R$  = risk free rate

$t$  = maturity

$\sigma$  = volatility of underlying stock

$N$  = Cumulative Normal distribution

Look @ PWP

Present value of strike price

$$C = SN(d_1) - \overbrace{Ee^{-Rt}}^{\text{Present value of strike price}} N(d_2)$$

$$d_1 = \frac{\ln\left(\frac{S}{E}\right) + \left(R + \frac{\sigma^2}{2}\right)t}{\sigma\sqrt{t}}$$

$$d_2 = d_1 - \sigma\sqrt{t}$$

## Example: OPM

- You are looking at a call option with 6 months to expiration and an exercise price of \$35. The current stock price is \$45 and the risk-free rate is 4%. The standard deviation of underlying asset returns is 20%. What is the value of the call option?

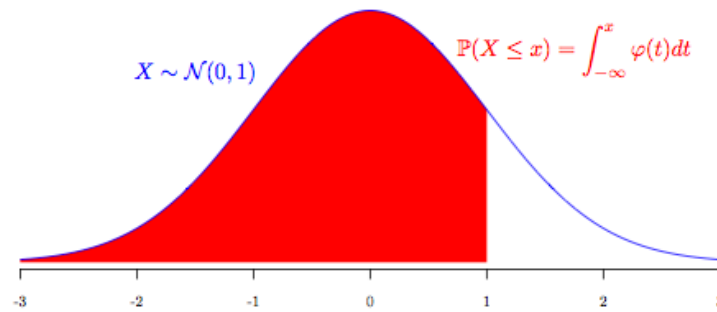
- Look up  $N(d1)$  and  $N(d2)$  in Table

- $N(d1) = (.9761 + .9772)/2 = .9767$

- $N(d2) = (.9671 + .9686)/2 = .9679$

$$C = 45(.9767) - 35e^{-.04(.5)}(.9679)$$

31  $C = \$10.75$



	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0.0	0.5000	0.5040	0.5080	0.5120	0.5160	0.5199	0.5239	0.5279	0.5319	0.5359
0.1	0.5398	0.5438	0.5478	0.5517	0.5557	0.5596	0.5636	0.5675	0.5714	0.5753
0.2	0.5793	0.5832	0.5871	0.5910	0.5948	0.5987	0.6026	0.6064	0.6103	0.6141
0.3	0.6179	0.6217	0.6255	0.6293	0.6331	0.6368	0.6406	0.6443	0.6480	0.6517
0.4	0.6554	0.6591	0.6628	0.6664	0.6700	0.6736	0.6772	0.6808	0.6844	0.6879
0.5	0.6915	0.6950	0.6985	0.7019	0.7054	0.7088	0.7123	0.7157	0.7190	0.7224
0.6	0.7257	0.7291	0.7324	0.7357	0.7389	0.7422	0.7454	0.7486	0.7517	0.7549
0.7	0.7580	0.7611	0.7642	0.7673	0.7704	0.7734	0.7764	0.7794	0.7823	0.7852
0.8	0.7881	0.7910	0.7939	0.7967	0.7995	0.8023	0.8051	0.8078	0.8106	0.8133
0.9	0.8159	0.8186	0.8212	0.8238	0.8264	0.8289	0.8315	0.8340	0.8365	0.8389
1.0	0.8413	0.8438	0.8461	0.8485	0.8508	0.8531	0.8554	0.8577	0.8599	0.8621
1.1	0.8643	0.8665	0.8686	0.8708	0.8729	0.8749	0.8770	0.8790	0.8810	0.8830
1.2	0.8849	0.8869	0.8888	0.8907	0.8925	0.8944	0.8962	0.8980	0.8997	0.9015
1.3	0.9032	0.9049	0.9066	0.9082	0.9099	0.9115	0.9131	0.9147	0.9162	0.9177
1.4	0.9192	0.9207	0.9222	0.9236	0.9251	0.9265	0.9279	0.9292	0.9306	0.9319
1.5	0.9332	0.9345	0.9357	0.9370	0.9382	0.9394	0.9406	0.9418	0.9429	0.9441
1.6	0.9452	0.9463	0.9474	0.9484	0.9495	0.9505	0.9515	0.9525	0.9535	0.9545
1.7	0.9554	0.9564	0.9573	0.9582	0.9591	0.9599	0.9608	0.9616	0.9625	0.9633
1.8	0.9641	0.9649	0.9656	0.9664	0.9671	0.9678	0.9686	0.9693	0.9699	0.9706
1.9	0.9713	0.9719	0.9726	0.9732	0.9738	0.9744	0.9750	0.9756	0.9761	0.9767
2.0	0.9772	0.9778	0.9783	0.9788	0.9793	0.9798	0.9803	0.9808	0.9812	0.9817
2.1	0.9821	0.9826	0.9830	0.9834	0.9838	0.9842	0.9846	0.9850	0.9854	0.9857
2.2	0.9861	0.9864	0.9868	0.9871	0.9875	0.9878	0.9881	0.9884	0.9887	0.9890
2.3	0.9893	0.9896	0.9898	0.9901	0.9904	0.9906	0.9909	0.9911	0.9913	0.9916
2.4	0.9918	0.9920	0.9922	0.9925	0.9927	0.9929	0.9931	0.9932	0.9934	0.9936
2.5	0.9938	0.9940	0.9941	0.9943	0.9945	0.9946	0.9948	0.9949	0.9951	0.9952
2.6	0.9953	0.9955	0.9956	0.9957	0.9959	0.9960	0.9961	0.9962	0.9963	0.9964
2.7	0.9965	0.9966	0.9967	0.9968	0.9969	0.9970	0.9971	0.9972	0.9973	0.9974
2.8	0.9974	0.9975	0.9976	0.9977	0.9977	0.9978	0.9979	0.9979	0.9980	0.9981
2.9	0.9981	0.9982	0.9982	0.9983	0.9984	0.9984	0.9985	0.9985	0.9986	0.9986
3.0	0.9987	0.9987	0.9987	0.9988	0.9988	0.9989	0.9989	0.9989	0.9990	0.9990