Derivatives and Risk Management in Commodity Markets

Topic 1: Introduction to futures and forwards

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Topics

- Introduction to derivatives
- Introduction to forwards and futures
- Introduction to options
  - Payoff/profit
  - Properties of options
  - Portfolio of options / trading strategies

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Introduction: Objectives

- What is a derivative?
- How are they traded?
- What are forward contracts?
  - What are payoff diagrams/profiles?
- What are futures contracts?
- What are options?
- Who are the participants in the derivatives markets?

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Learning objectives: Mechanics of Futures Markets

- What are the major markes for futures contracts?
- How do you take a position in a futures contract?
  - Positions, Quotes, Types of orders
  - Margins, clearing, Profit and Loss (PnL or P&L)
- What are typical specifications (specs) in a Futures contract?
- What do we mean by convergence of futures price to spot prices?
- What is the difference between a forward and a futures contract?

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Learning objectives: Characteristics of options

- Know the difference between forwards/futures and options wrt
  - Contractual specification
  - Payoff function and diagrams
- Know what moneyness means
- Know the difference between European and American options
- Know the 6 most important factors affecting the value of options, and especially the direction they affect the option values

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Learning objectives: Option payoff/profit & option strategies

- Know the difference between payoff functions, payoff diagrams and profit diagrams
- Know the most common option strategies and why they are used

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Introduction to derivatives

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Derivatives

- Derivatives as an asset class have become increasingly important in the last 25-30 years
- But, has had a much longer history than that
- Futures and options are traded actively on many exchanges throughout the world
- Many types of forward contracts, swaps, options and other derivatives are regularly traded by financial institutions, fund managers and corporate treasuries in the over-the-counter market (OTC)

Introduction: topics

- Markets
  - Exchange traded markets
  - Over-the-counter markets (OTC)
  - Structured products
- Types of derivative contracts
  - Forward contracts
  - Futures contracts
  - Options
- Types of traders
  - Hedgers
  - Speculators
  - Arbitrageurs
- Dangers

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Derivatives

- Exists as separate financial assets, or
- embedded in other products
- included in executive compensation plans

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Markets

- Derivative: ”A derivative can be defined as a financial instrument whose value depends on (derives from) the values of other, more basic, underlying variables

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Derivative

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Markets

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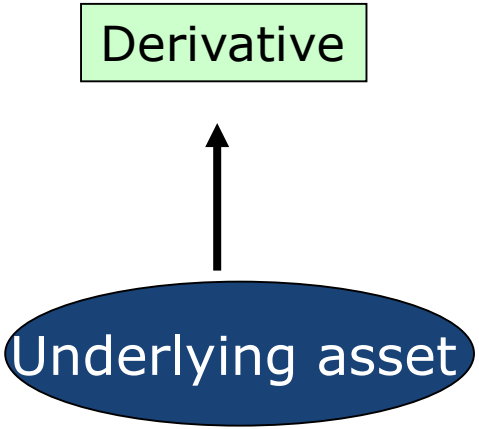

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Markets

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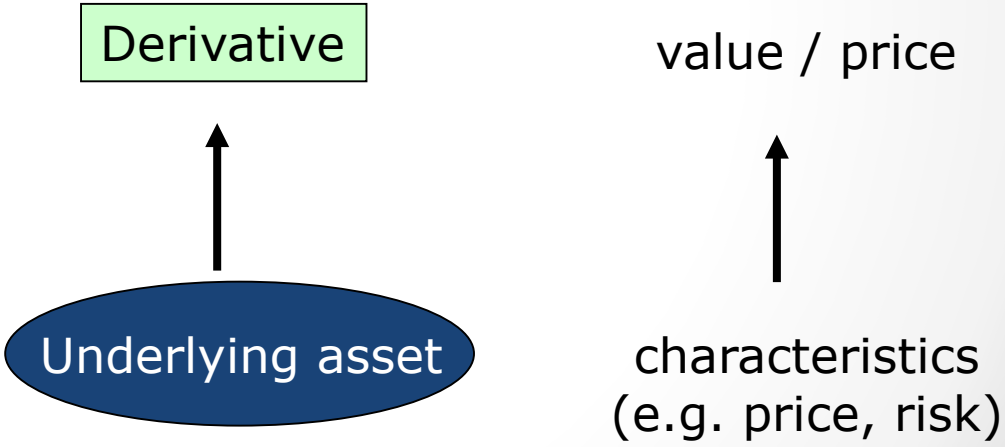

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The underlying asset

- Stocks (e.g. stock option) & Stock indices
- Bonds (credit derivatives)
- Energy (crude oil, natural gas, power, emissions)
- Commodities
  - Agriculture (grain, pork belly, cattle, sugar, etc).
  - Metals
  - Energy

- Weather (amount of snow, temperature)
- Insurance derivatives

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Types of markets

- 1. Exchange traded
- 2. Over-the-counter (OTC)
- 3. Not directly sold (embedded, real options, etc.)

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Exchange traded options

- A derivatives exchange is a market where individuals trade **standardized** contracts that have been defined by the exchange

- Examples
  - Chicago board of trade (CBOT)
  - Chicago mercantile exchange (CME)
  - Chicago board options exchange (CBOE)
  - New York M exchange (NYMEX)
  - (ICE)

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Over-the-counter markets (OTC)

- Important alternative to exchanges
- Larger volumes than exchanges
- Telephone and computer linked network of dealers/brokers
  - Financial institutions often act as market makers for the more commonly traded instruments
  - Benifit: more flexible with respect to terms
  - Downside: credit risk

Main types of financial derivatives contracts

- Forward
- Futures
- Options
- Swaps

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Introduction to forwards and futures

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Forward contract

- A ***forward contract*** is an agreement (contract) to buy or sell an asset at a certain future time for a certain price

- is an agreement (Forward contract)
- buy / sell an asset (trade Underlying asset)
- at future time (Maturity)
- for a certain price (Forward price)

- A ***spot contract*** is an agreement to buy/sell an asset today

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Forward contracts

Spot/forward quotes for USD/GBP foreign exchange rate (FX)

Delivery (maturity)	Bid price	Offer price
Spot	1.6281	1.6285
1 month forward	1.6248	1.6253
3-month forward	1.6187	1.6192
5-month forward	1.6094	1.6100

GBP = British pounds
USD = US dollar
Bid = number of dollars you receive when you sell 1 pound
Offer = number of dollars you have to pay to buy 1 pound

Forward contracts

	2.sep	2. oct	2. dec	2. feb
	spot	1-month	3-month	5-month
sell	1.6281	1.6248	1.6187	1.6094
buy	1.6285	1.6253	1.6192	1.6100

time

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Forward contracts

- Example 1

- you have 1000 pounds you want to exchange for dollars today. How many dollars will you receive?

- The spot Bid price is 1.6281
- USD = 1.6281 USD/GBP x 1000 GBP = 1628.1 USD

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Forward contracts

- Example 2

- you have 1000 dollars you want to exchange for pounds 3 months from now. How many pounds will you have to pay?

- You need the 3-month offer price for USD/GBP
- This is the same as the 3-month bid price for GBP/USD
- The 3-month bid price is 1.6187
- GBP = 1000 USD / 1.6187 USD/GBP = 617.8 GBP

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Payoffs from forward contracts

- Example: you enter into a forward contract to buy 1 million GBP in 6 months time

- Alternative 1
  - buy forward at rate 1.6100 USD/GBP

- Alternative 2
  - wait 6 months, and buy spot at price X (uncertain)

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Payoffs from forward contracts

- If the spot rate rose to 1.700 after 6 months, what is the forward contract worth?

- Alternative 1:
  - buy forward at 1.6000
  - pay 1 610 000 USD in 6 months and receive GBP 1 000 000
  - you could then sell 1 000 000 GBP you would then receive 1 700 000 USD
  - profit (mark-to-market) = 1 700 000 – 1 610 000 = 90 000 USD

- Alternative 2: no profit (payoff = 0)

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Payoff diagrams

- The payoff from a long position in a forward contract is:

$$S_T - F$$

- The payoff from a short position in a forward contract is:

$$F - S_T$$

S_T = spot price at maturity
F = forward price

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Long or short?

- Long: you have bought something
- Short: you have sold something
- Long forward: you are buying something in the future and are paying the forward price
- Short forward: you are selling something in the future and are receiving the forward price

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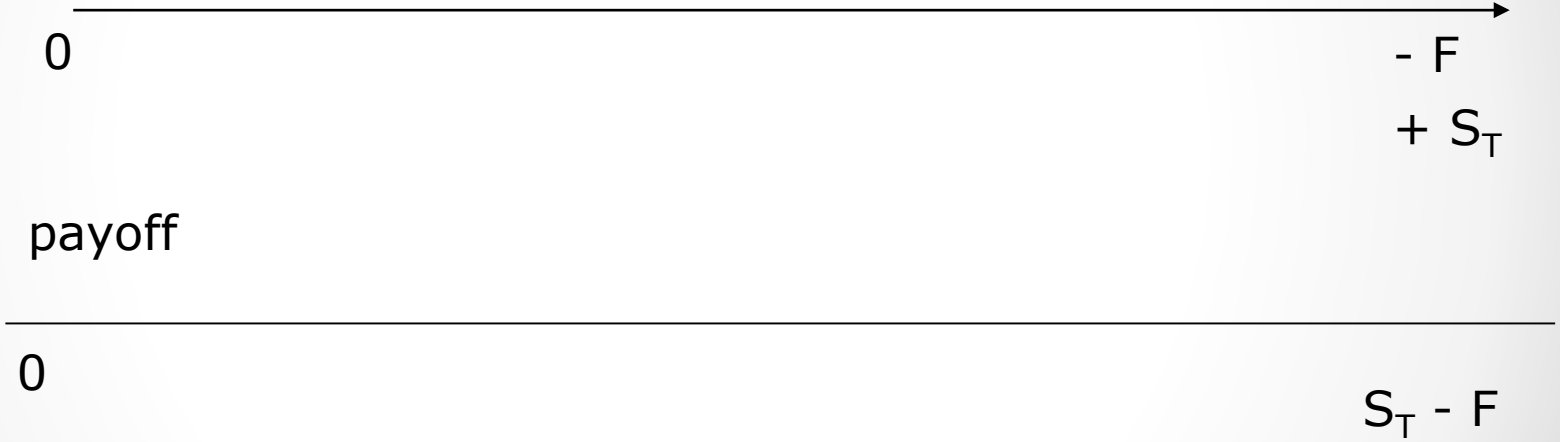
Long or short?

long forward



The cost of entering a forward contract (now) is 0!

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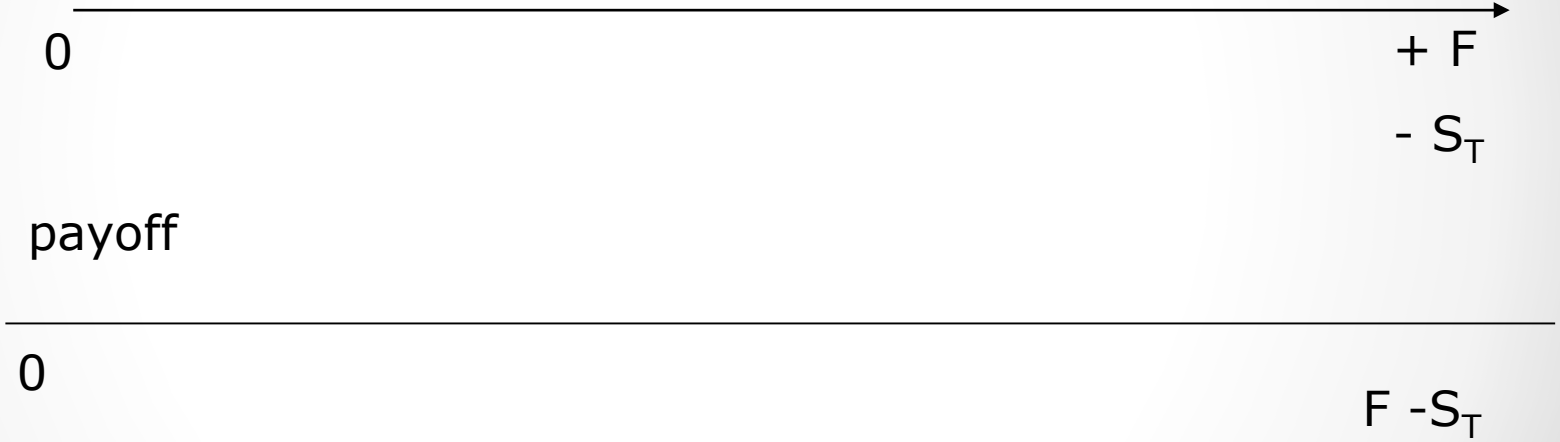
Long or short?

short forward



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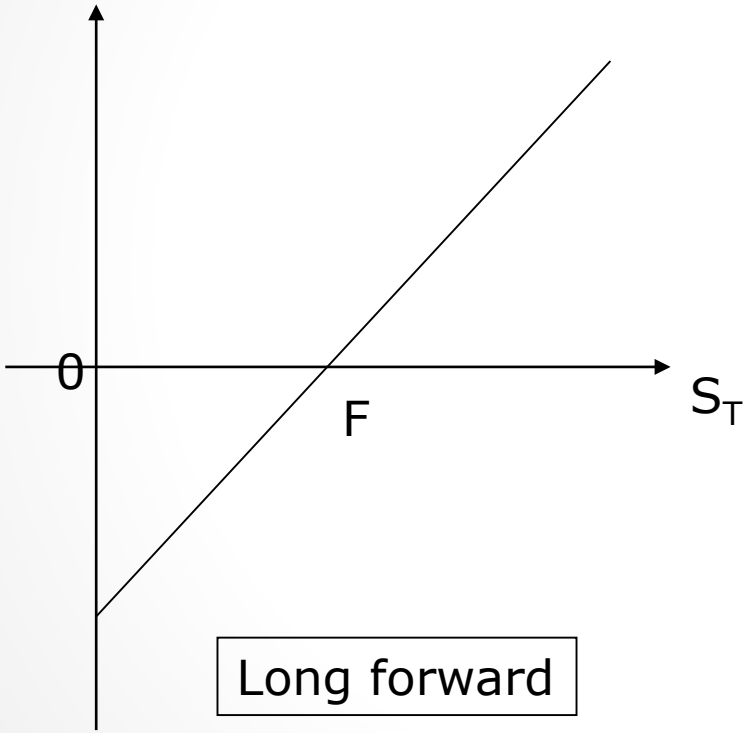
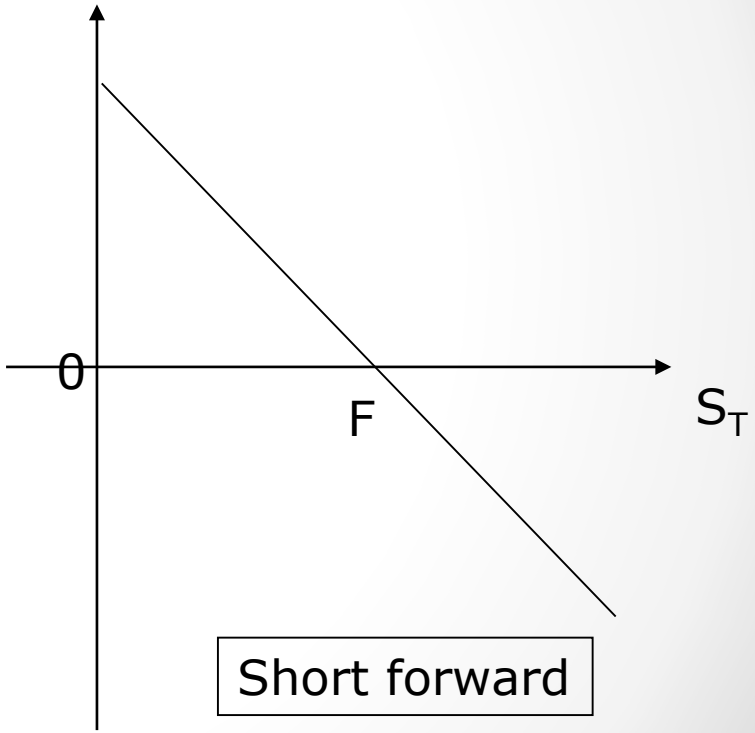
Payoff diagram (exposure towards the underlying asset)





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Futures contracts

- A futures contract is an agreement between two parties to buy or sell an asset at a certain time in the future for a certain price (same as forward contract)

- Traded on an exchange
- Standardized contract
- Market clearing mechanism

Closing out positions

- Financial – settled in cash
- Physical – settled by physical delivery

- Most settled in cash
  - long position -> sell same contract (short)
  - short position -> buy same contract (long)

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Specification of a futures contract

- The asset (underlying)
- The contract size
- Delivery arrangements
- Delivery month (trading ends before delivery)
- Price quotes
- Price limits and position limits

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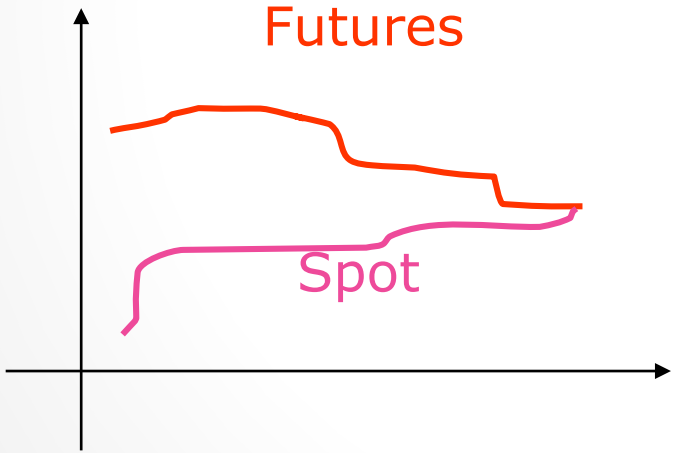
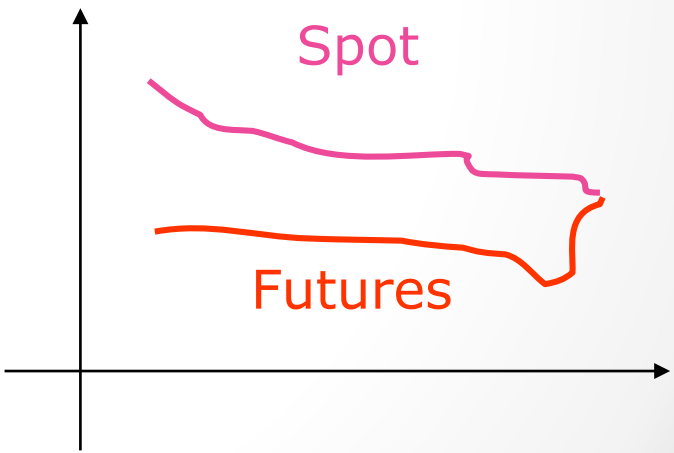
Convergence of futures price to spot price

- As the delivery period for a futures contract is approached, the futures price converges to the spot price of the underlying asset





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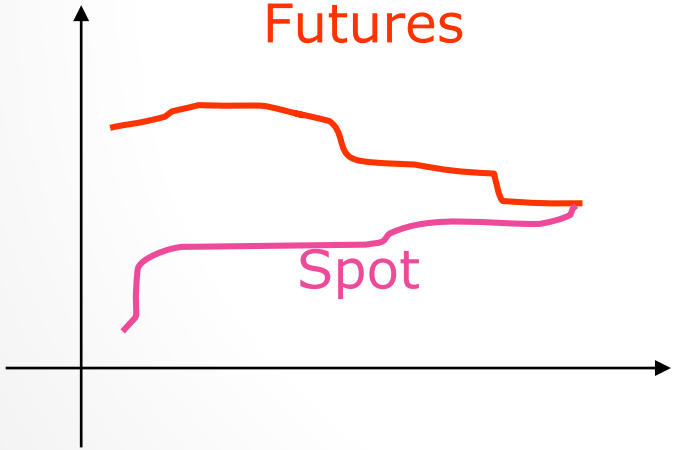
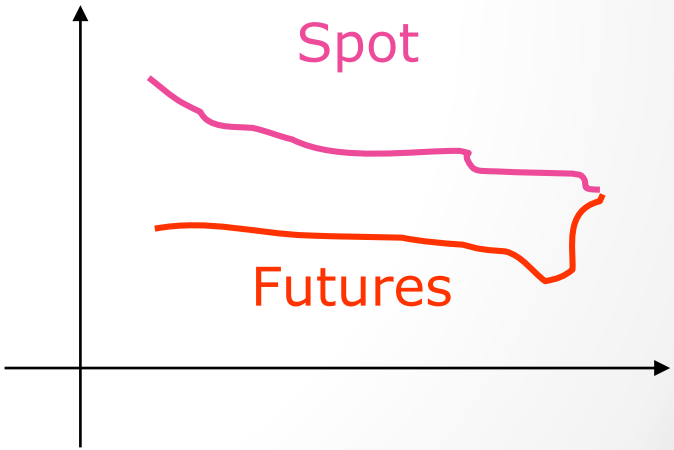
Convergence of futures price to spot price

- The contracts have to converge, otherwise there is an arbitrage opportunity
- Not the same contract prior to delivery of futures, but become the same contract at delivery





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Daily settlement and margin

- One of the key roles of the exchange is to organise trading so that contract defaults are avoided
- Use margins
- Basically, if the loss exedes the margin, the position is liquidated (position is closed out)

Daily settlement and margin

- Example: On August 25th an investor contacts his/her broker to buy 2 Dec'10 WTI (crude oil) futures contracts

- Type of asset: WTI Crude
- Delivery period: December '10 (trading ends in september 2010)
- Size of contract: 1000 US barrels
- Number of contracts: 2
- Futures price: 75.74 USD/bbl
- Initial margin: $2000/contract
- Maintenance margin: $1500/contract

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Daily settlement and margin

Total position (size of exposure)

- #contracts x size of contract x futures price
- 2 x 1000 x 75.74 = $151,480

Initial margin (deposit to margin account)

- #contracts x margin per contract
- 2 x $2000 = $4,000

- At the end of the day, the margin account is adjusted to reflect the investor's gain or loss (marking-to-market)

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Daily settlement and margin

Maintenance margin

- If the margin account falls below the maintenance margin, the investor receives a margin call and is expected to top up the margin account. Extra funds are deposited (variation margin)
- If the investor does not provide the variation margin, the broker closes the position by selling the contract

Daily settlement and margin

Example

Day	Oil Price	Position	Daily gains/losses	Margin account	Margin call
0	75.74	151,480	0	4000	
1	75.80	151,600	120	4,120	
2	76.00	152,000	400	4,520	
3	74.50	149,000	-3,000	1,520	2480
4	74.10	148,200	-800	3,200	
5	73.50	147,000	-1,200	2,000	2000
6	75.00	150,000	3,000	7,000	
7	76.00	152,000	2,000	9,000	
8	77.50	155,000	3,000	12,000	
9	79.00	158,000	3,000	15,000	
10	85.00	170,000	12,000	27,000	

Clearing house

- The exchange clearing house is an adjunct of the exchange and acts as an intermediary in the futures transaction

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Forward vs futures contract

Forward contract	Futures contract
Private contract between two parties	Traded on an exchange
Not standardized	Standardised contract
Usually one specified delivery date	Range of delivery dates
Settled at end of contract	Settled daily
Delivery or final cash settlement usually takes place	Contract is usually closed out prior to maturity
Some credit risk	Virtually no credit risk

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Marking to market

- Profit / loss of taking a position in a derivative
- Compared to the market price of the underlying

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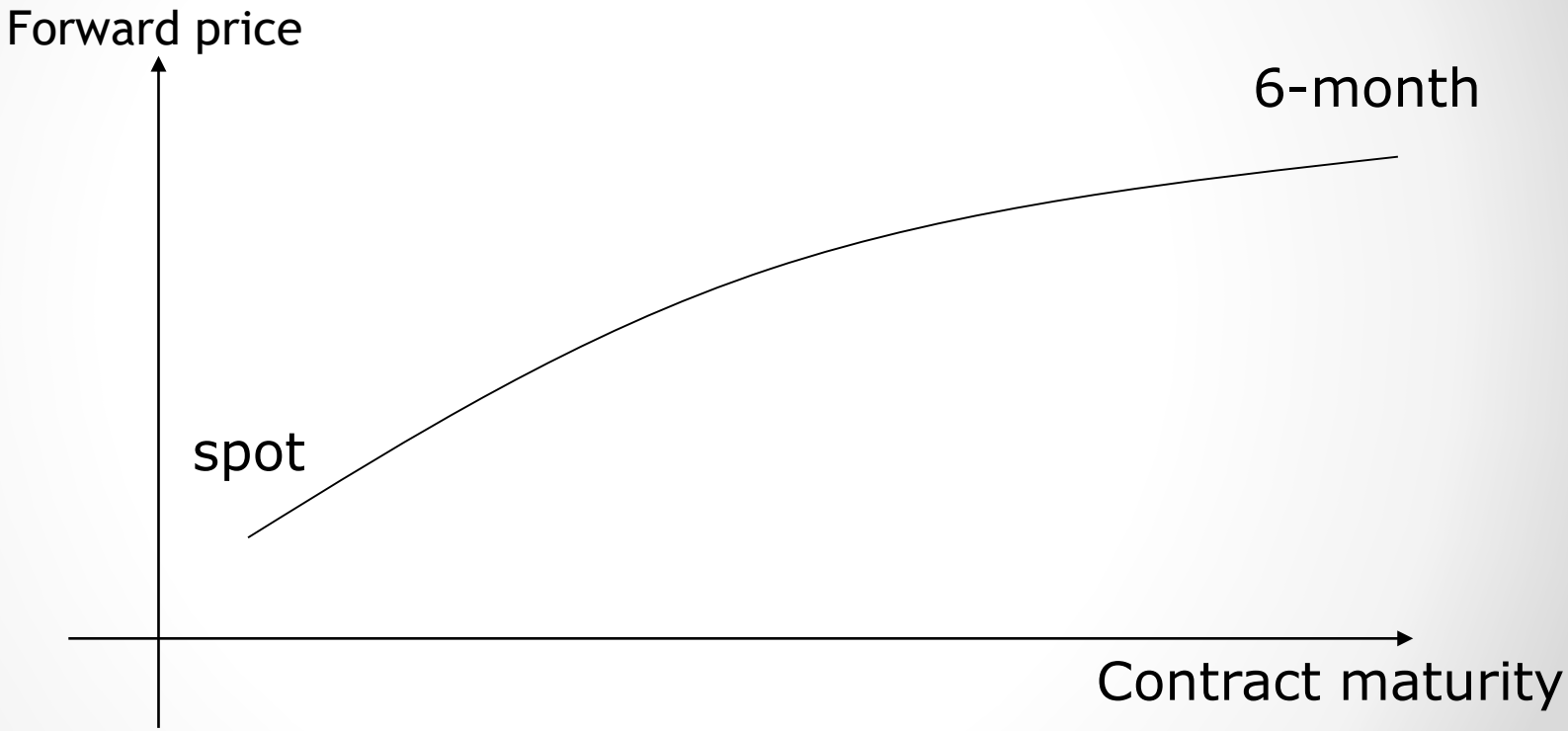
The forward (futures) curve



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Exercise: Build your own forward curve

- Data:
  - www.cmegroup.com for commodities
  - www.cboe.com for equity index futures
  - finance.yahoo.com for equities, commodities etc..
- What is the shape of the forward curve?
- How do the shapes of forward curves for Natural Gas prices compare to Crude oil prices?

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Trading forwards/futures

- Example: Natural Gas (e.g. Henry Hub front month)

		price quotes (pence/therm)	
		bid	offer
24/08/2009	Day ahead (spot)	18.00	18.10
	September '10	19.20	19.30
	October '10	25.85	26.05
	November '10	34.60	35.00

- You decide to go long Sep'10 and short Oct'10
- What are the relevant prices?

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- You decide to go long Sep'10 and short Oct'10
- What are the relevant prices?
  - long Sep'10: 19.30 (offer)
  - short Oct'10: 28.85 (bid)
- When do you earn money on these transactions?

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Trading forwards/futures

- What does the Sep'10 price have to be to earn money?
  - Sep'10: Ft > 19.30 (bid)
- What does the Oct'10 price have to be to earn money?
  - Oct'10: Ft <28.85 (offer)

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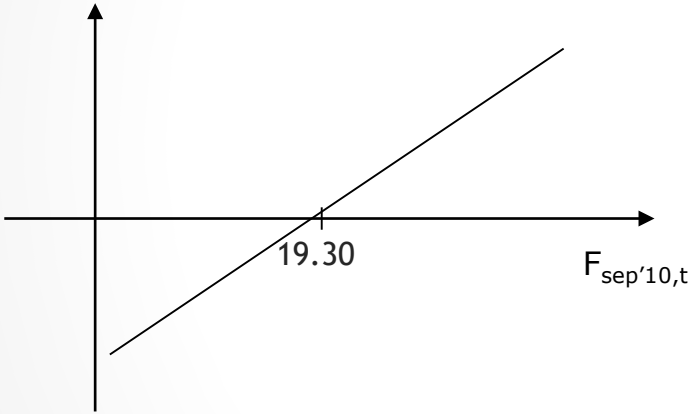
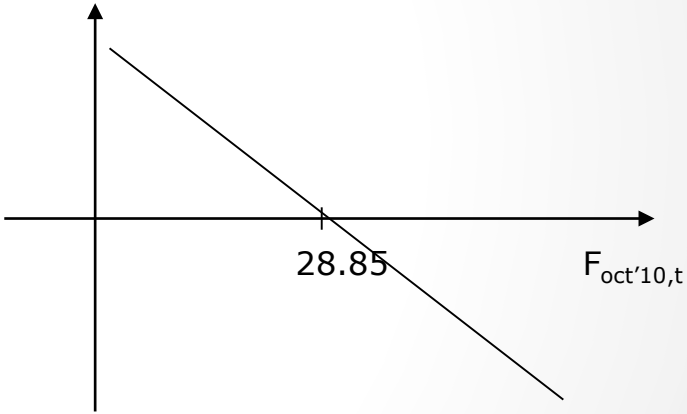
Trading forwards/futures





Payoff = $F_{sep'10,t} - 19.30$

Payoff = $28.85 - F_{oct'10,t}$

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Trading forwards/futures

- One day later the prices are

		price quotes (pence/therm)	
		bid	offer
25/08/2009			
	September '10	20.20	20.30
	October '10	23.35	23.55
	November '10	34.50	34.90

- What is the profit on your positions?
- Sep'10 payoff = 20.20 – 19.30 = 0.90 pence/therm
- Oct'10 payoff = 28.85 – 23.55 = 5.30 pence/therm

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Exercise: calculate your own trading profits/losses

- Data: US Energy futures historical data:
- Gas prices
- http://www.eia.gov/dnav/ng/ng_pri_fut_s1_d.htm

- Crude oil prices
- http://www.eia.gov/dnav/pet/pet_pri_fut_s1_d.htm

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Introduction to options

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Options

- A forward contract is non-flexible. You have the obligation to buy (long) or sell (short) the underlying some time in the future

- An option is flexible (only long position). You have the right (but not the obligation) to buy or sell the underlying asset at a specific time in the future at a specific price

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Options

- A forward contract is non-flexible. You have the obligation to buy (long) or sell (short) the underlying some time in the future

- An option is flexible (only long position). You have the right (1) (but not the obligation) to buy (2) or sell (3) the underlying asset at a specific time in the future (4) at a specific price (5)

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Options

- An option is flexible (only long position). You have the right (1) (but not the obligation) to buy (2) or sell (3) the underlying asset at a specific time in the future (4) at a specific price (5)

1. The right but not the obligation (an Option)
2. Buy underlying asset (Call option)
3. Sell underlying asset (Put option)
4. A specific time in the future (Maturity / Exercise date / expiration date)
5. A specific price (Exercise price / strike price, X)

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Keywords

- Flexibility
- Put/Call
- Long/short
- Payoff
- Maturity / Exercise
- Exercise price
- Moneyness

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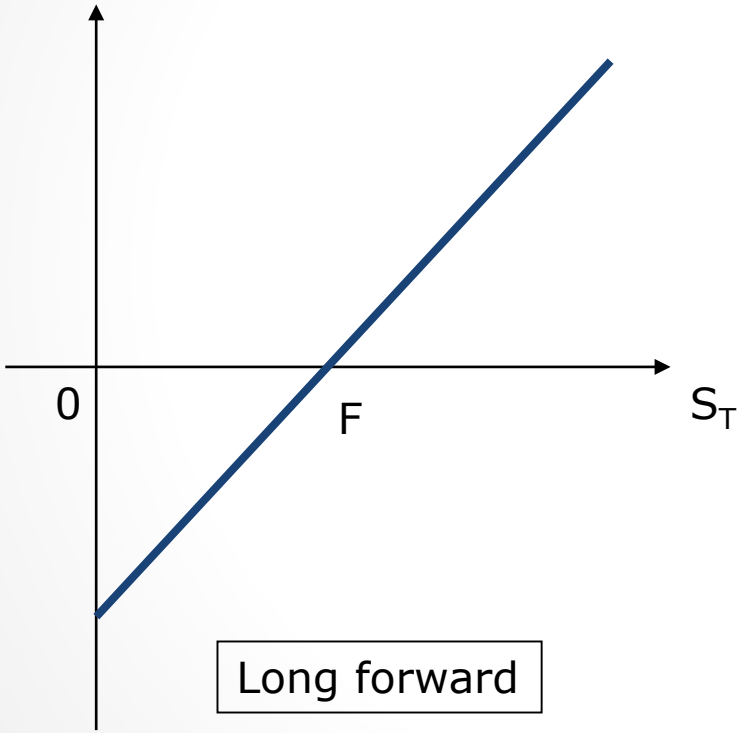
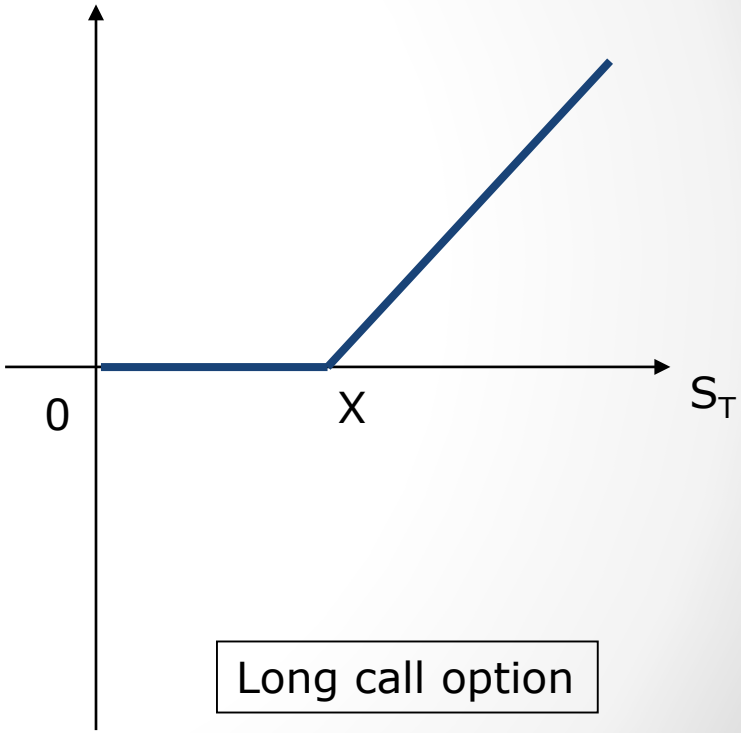
Option vs forward





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Payoff

- Forward contract (long)

$$S_T - F$$

- Option contract (long call)

$$\max(S_T - X, 0)$$

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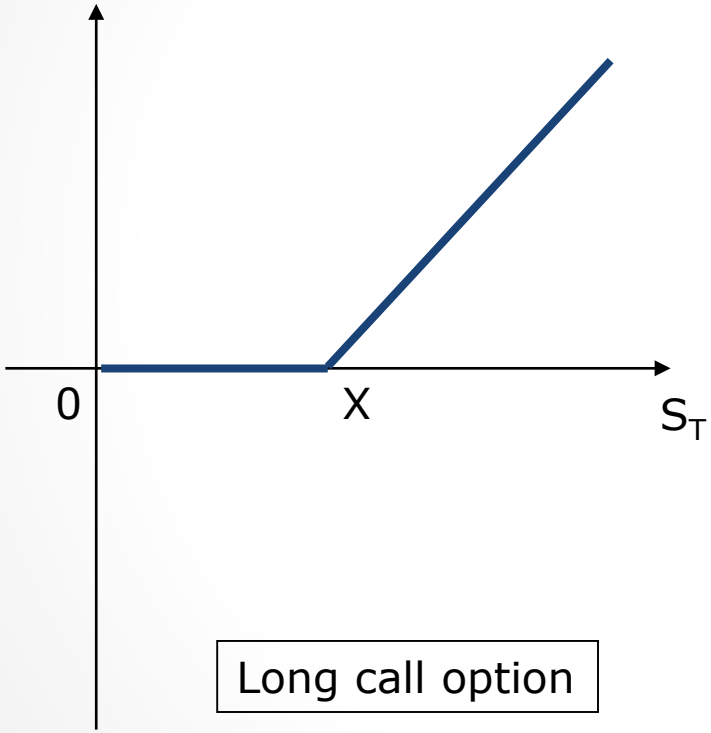
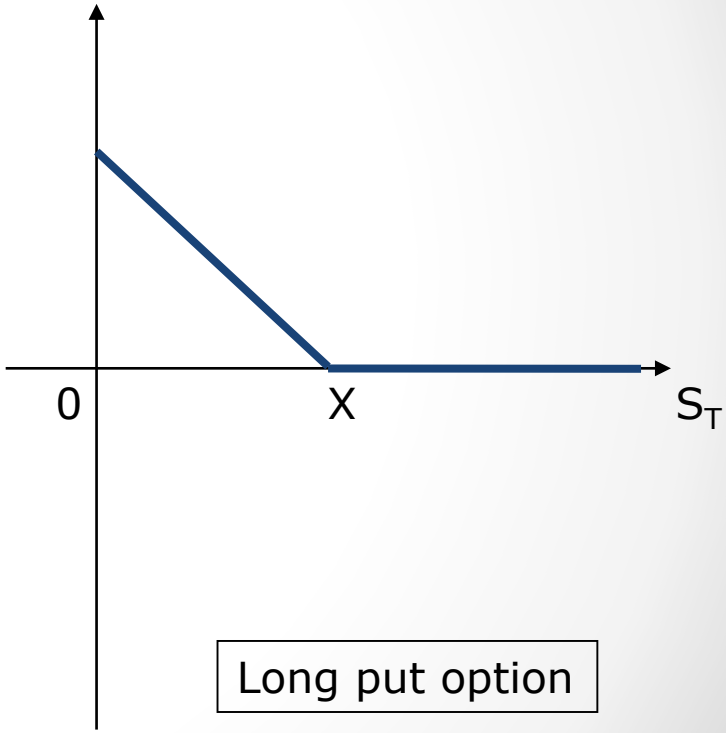
Call and put options



Long call option



Long put option

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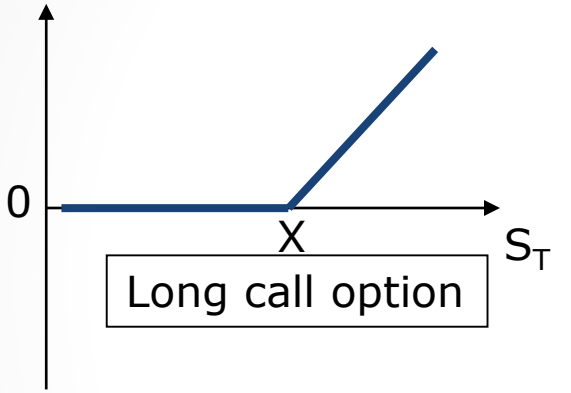
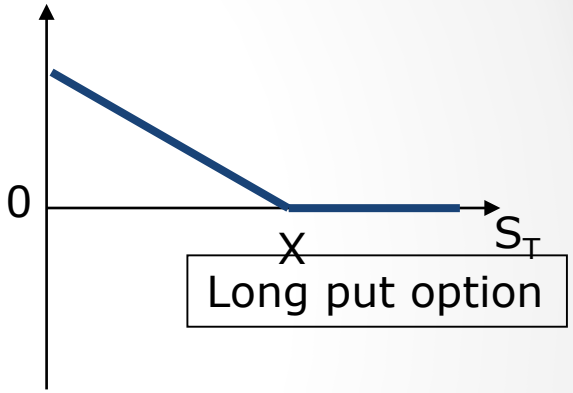
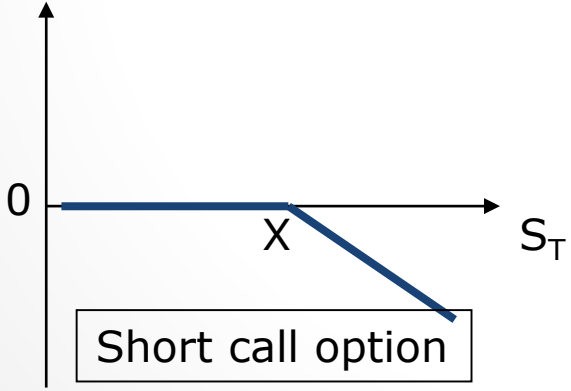
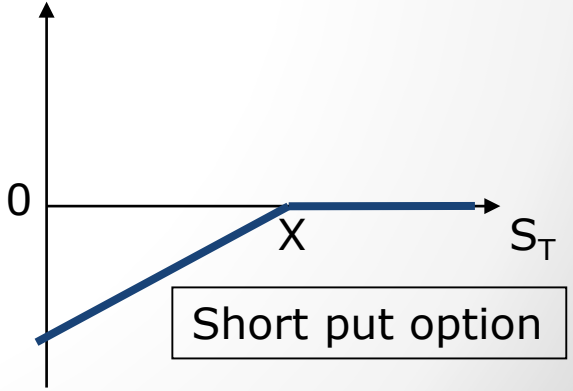
Call and put options (long and short)









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Examples

- What is the payoff of a long call (X = 50) if the spot price at maturity is 10, 20, 30, 40, 50, 60, 70, 80, 90, 100?
- What is the payoff of a long put (X = 50) if the spot price at maturity is 10, 20, 30, 40, 50, 60, 70, 80, 90, 100?
- What about a short call and a short put? What is the payoff?

Payoff at maturity

- Long call: $\max(S_T - X, 0)$
- Short call: $-\max(S_T - X, 0)$
- Long put: $\max(X - S_T, 0)$
- Short put: $-\max(X - S_T, 0)$

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Maturity

- European options
  - Expiry on a certain date
- American options
  - Expiry before and on a certain date
- Bermuda options

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Strike price

- European/American option
  - specific strike price
- Asian option
  - strike price is an average of previous spot prices

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Moneyness

- In the money (ITM)
- At the money (ATM)
- Out of the money (OTM)

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Types of traders

- Hedgers: use derivatives to reduce risk
- Speculators: use derivatives to bet on the future direction of a market
- Arbitrageurs: take positions in one or more instruments to lock in a profit
- These types of traders make up the market

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Properties of stock options

- Factors affecting option prices
- Assumptions and notation
- Upper and lower bounds for option prices
- Put-Call parity
- Early exercise

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Factors affecting option prices

- There are six factors affecting the price of a stock option

1. The current stock price, S_0
2. The strike price, **X**
3. The time to expiration, **T**
4. The volatility of the stock price, **σ**
5. The risk free interest rate, **r**
6. The dividends expected during the life of the option

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Factors affecting option prices

Variable	European call	European put	American call	American put
S_0	+	-	+	-
X	-	+	-	+
T	?	?	+	+
σ	+	+	+	+
r	+	-	+	-
Dividends	-	+	-	+

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Factors affecting option prices

- S_0, X
  - Value of an option at expiry:
    Call (long): max (S_T – X, 0)
    Put (long): max (X - S_T, 0)

- Time to expiration
  - The longer time to maturity, the more exercise opportunities

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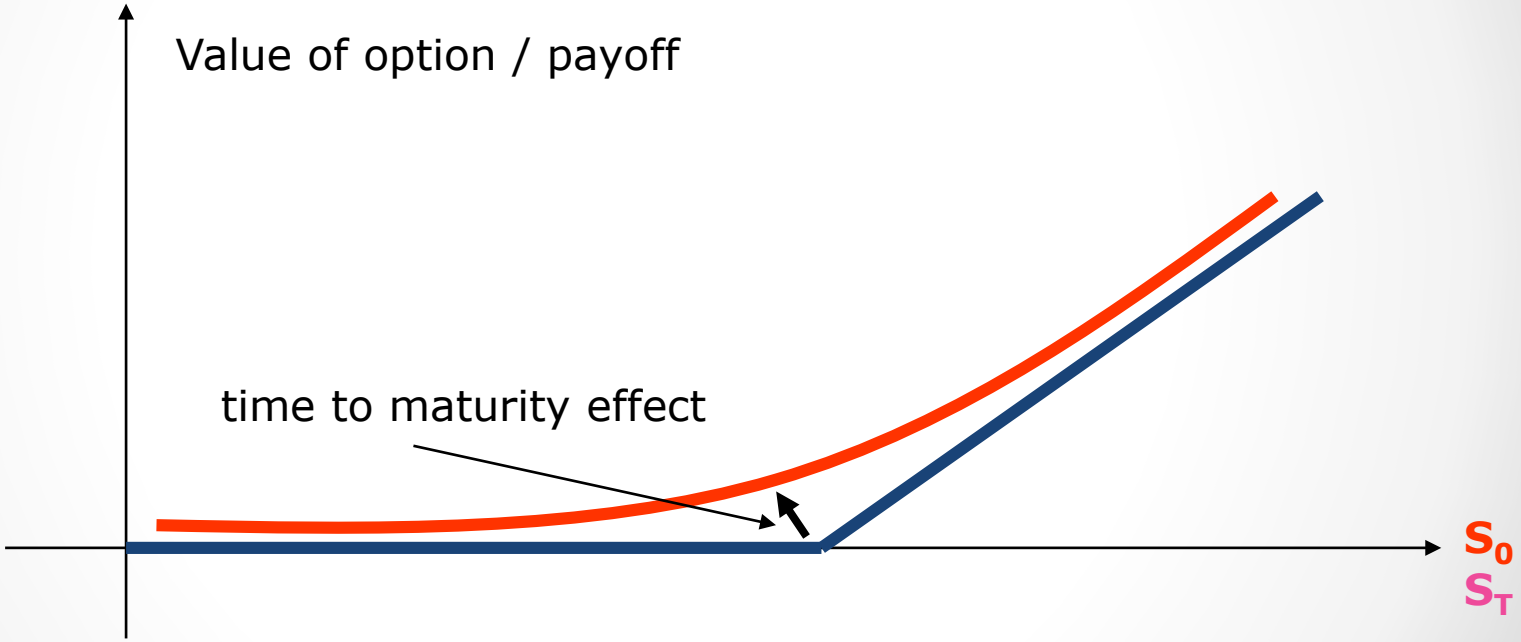
Time to expiration



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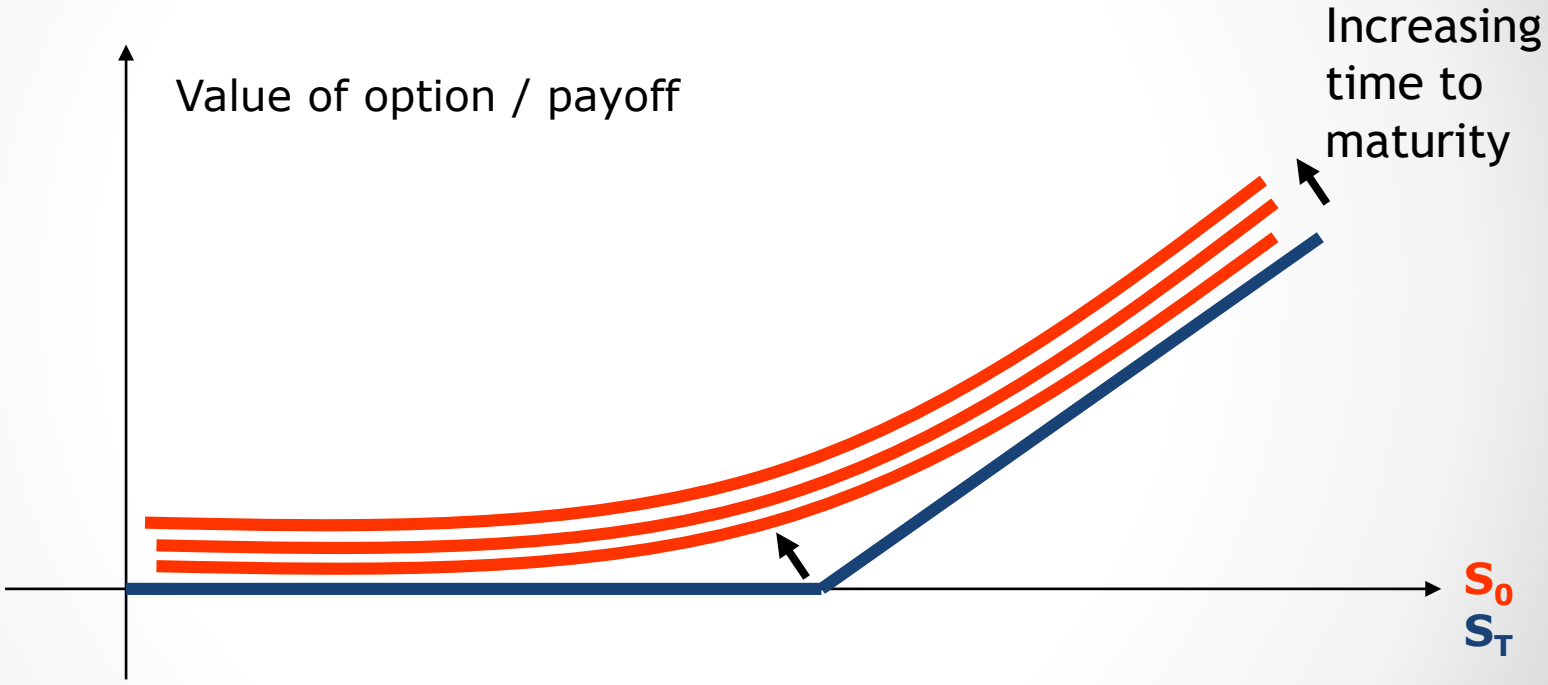
Time to expiration



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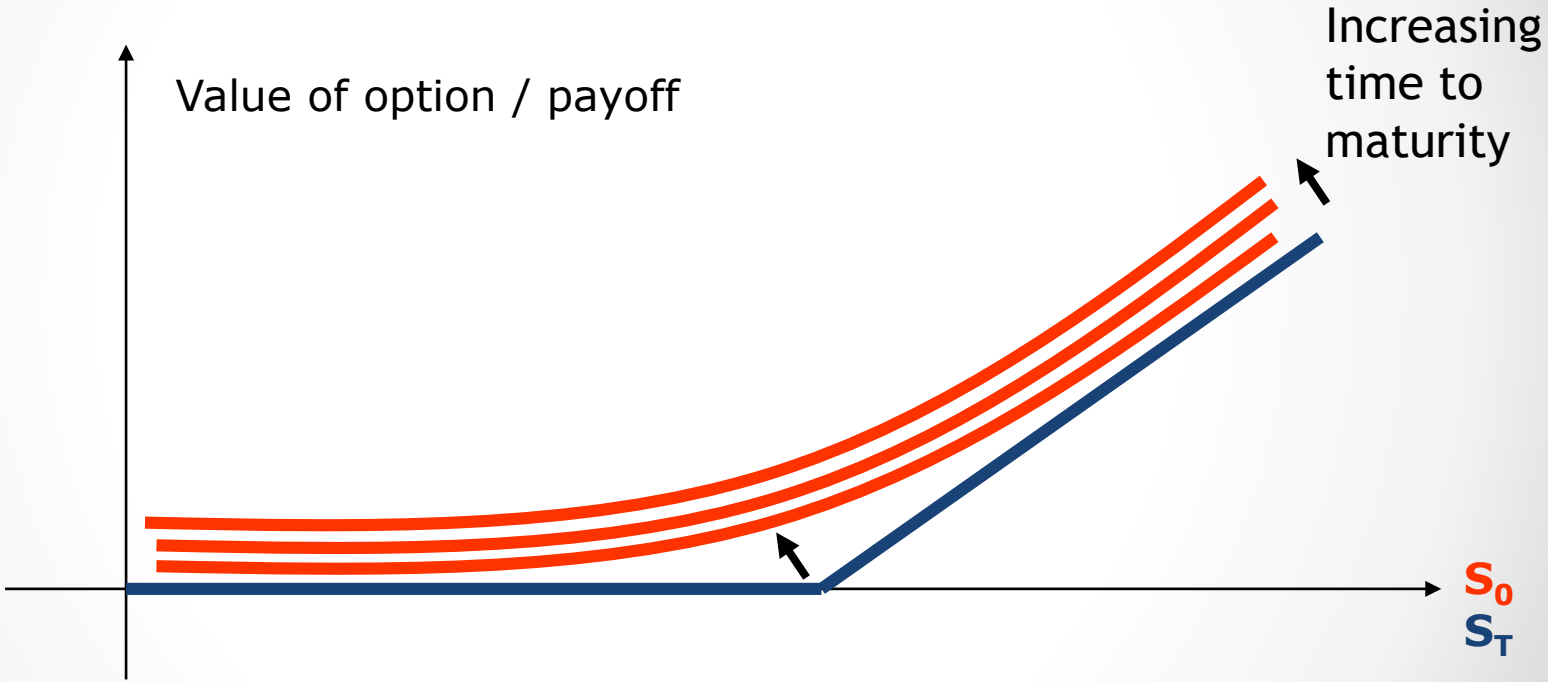
Time to expiration



Q: Why is the impact of time to maturity larger for ATM options than OTM options
A: We will revisit this when we look at option 'greeks'

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Factors affecting option prices

- Volatility
  - As volatility increases, the probability of a stock doing very well or very bad increases
    - Options remove the downside risk
    - Options become more valuable with increasing volatility
- Risk-free interest rate
  - not clearcut

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Assumptions and notation

- Assumptions:
- 1. There are no transaction costs
- 2. All trading profits (net of trading losses) are subject to the same tax rate
- 3. Borrowing and lending are possible at the risk-free interest rate

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Option portfolios & strategies

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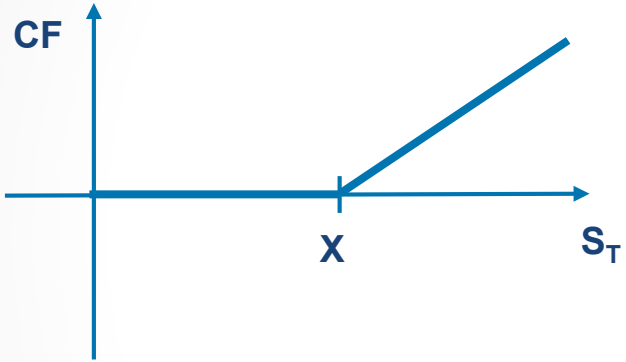
Call or put?

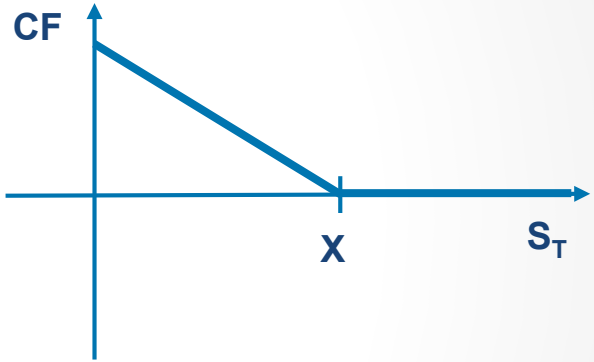
Call option



A right, but not an obligation, to ***buy*** the underlying asset at price X at some time in the future

$$CF_T = max\ (S_T - X,\ 0)$$

Put option



A right, but not an obligation, to ***sell*** the underlying asset at price X at some time in the future

$$CF_T = max\ (X - S_T,\ 0)$$

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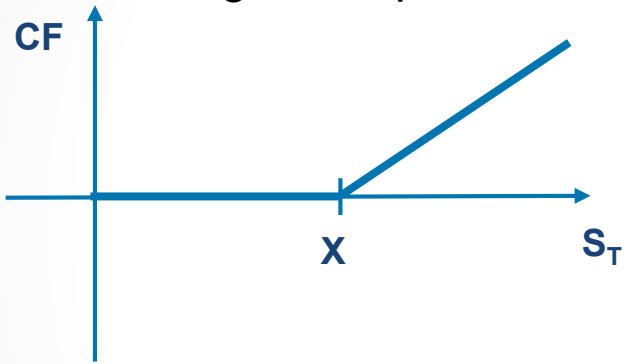
Long or short?

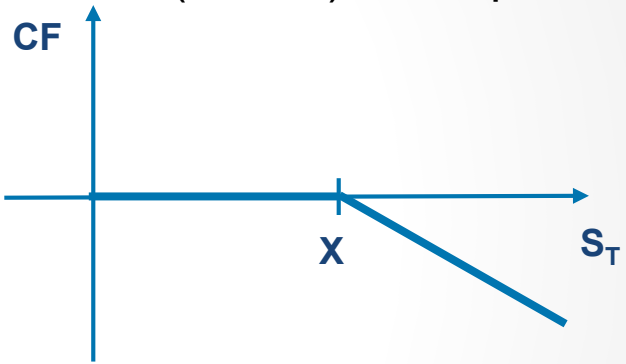
Long Call Option



A right, but not an obligation, to ***buy*** the underlying asset at price X at some time in the future

$$CF_T = max\ (S_T - X,\ 0)$$

Short (written) Call Option



An obligation to ***sell*** the underlying asset to the long option holder when the option is exercised

$$CF_T = -\ max\ (S_T - X,\ 0)$$

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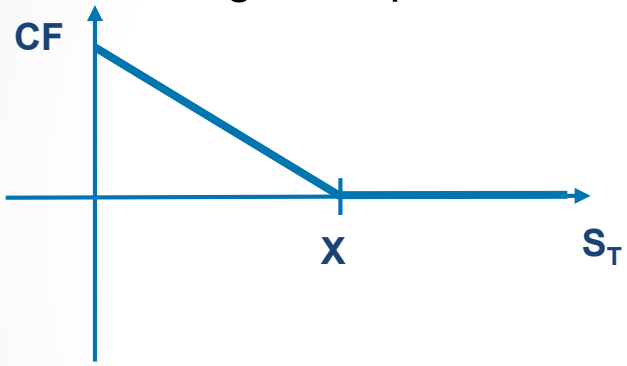
Long or short?

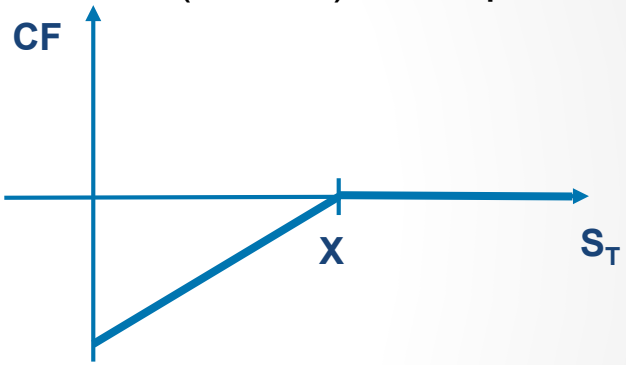
Long Put Option



A right, but not an obligation, to ***sell*** the underlying asset at price X at some time in the future

$$CF_T = max\ (X - S_T, 0)$$

Short (written) Put Option



An obligation to ***buy*** the underlying asset to the long option holder when the option is exercised

$$CF_T = -\ max\ (X - S_T, 0)$$

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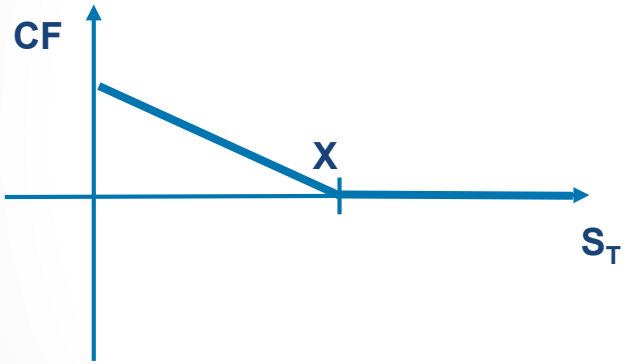
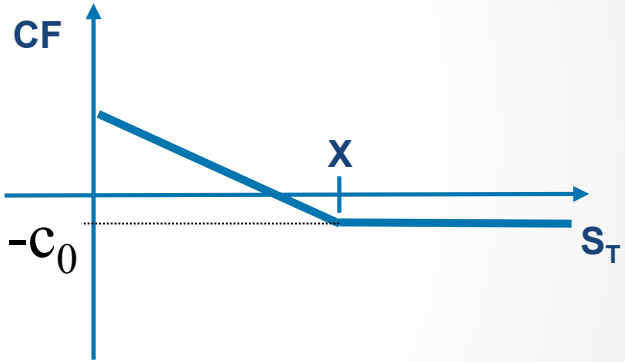
Payoff vs Profit diagrams

Payoff



Profit



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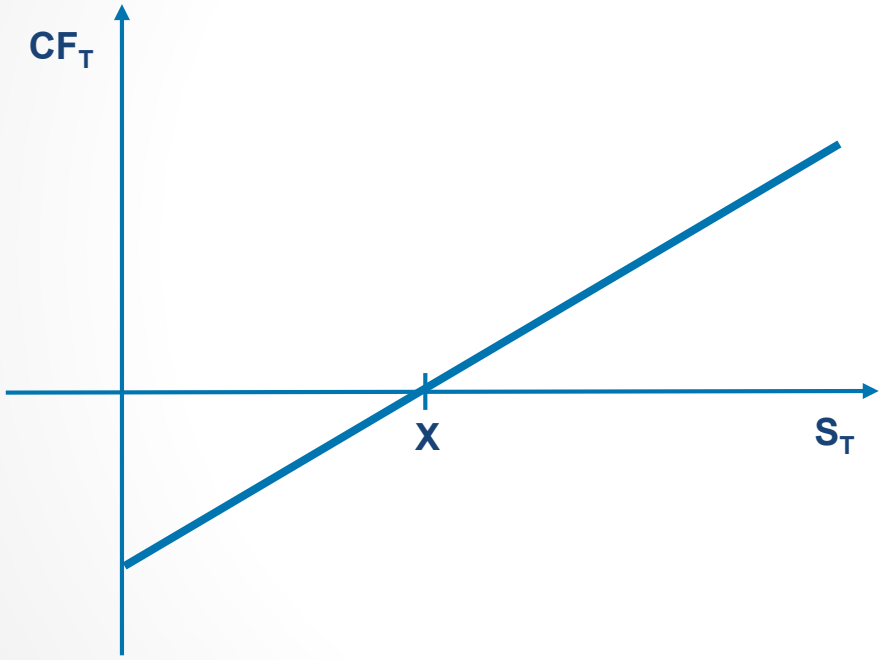
Combinations: synthetic call



Statoil produces crude oil

= long position in oil

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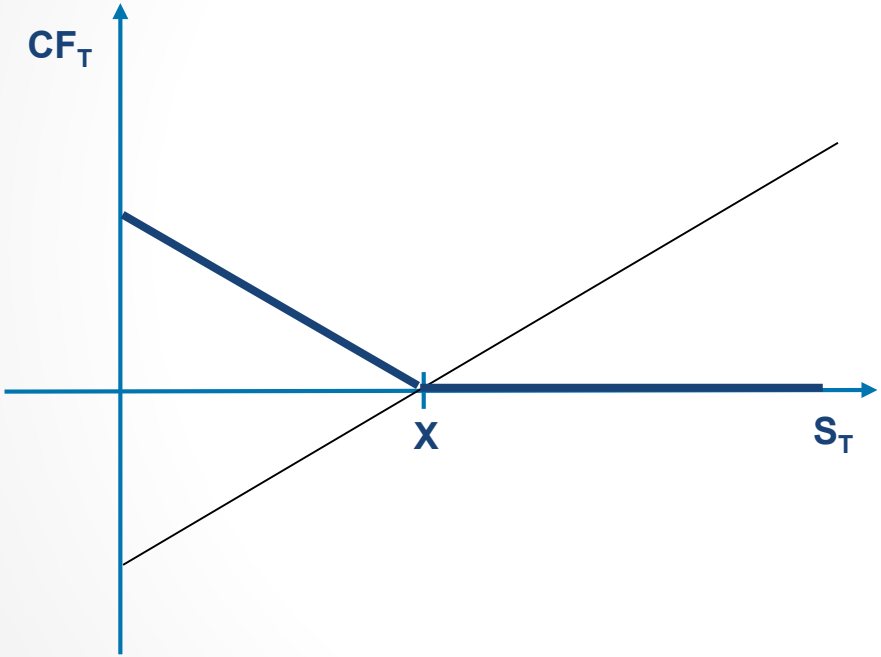
Combinations: synthetic call



Statoil produces crude oil

= long position in oil

Decides to hedge the downside with a put option

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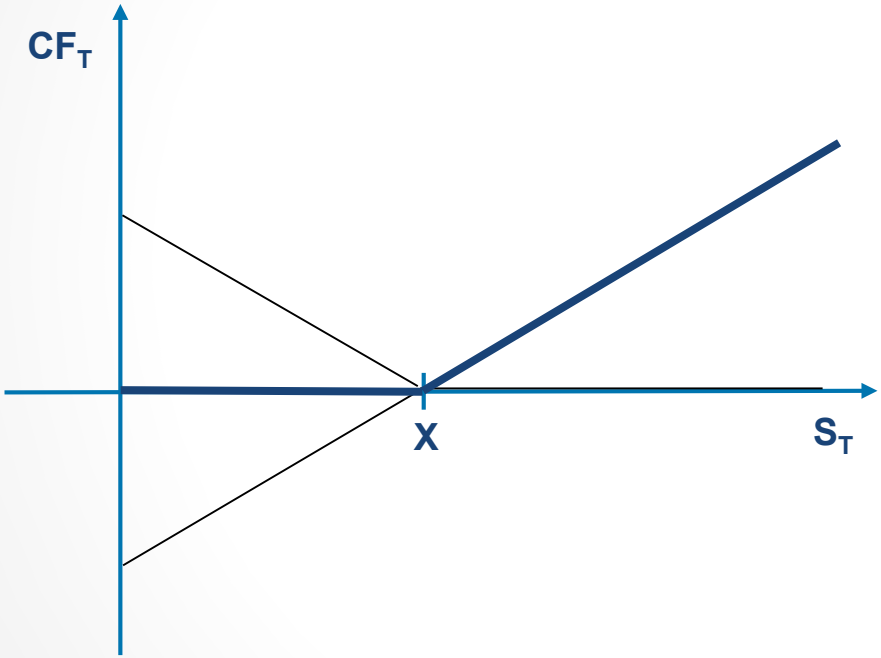
Combinations: synthetic call



Statoil produces crude oil

= long position in oil

Decides to hedge the downside with a long put option

The combination is a synthetic call option

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Combinations: synthetic call

- Cash flows
  - Strike price, X = 50
  - Purchase price, S_0 = 50
  - Sales price, S_T = 10, 20,.....,100

A. Stock purchase (long)

Spot price, St	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
Purchase price	-50	-50	-50	-50	-50	-50	-50	-50	-50	-50
Spot price	10	20	30	40	50	60	70	80	90	100
Profit	**-40**	**-30**	**-20**	**-10**	**0**	**10**	**20**	**30**	**40**	**50**

B. Put (long)

Spot price, St	**10**	**20**	**30**	**40**	**50**	**60**	**70**	**80**	**90**	**100**
Strike price	50	50	50	50	50	50	50	50	50	50
Spot price	10	20	30	40	50	60	70	80	90	100
Profit put	**40**	**30**	**20**	**10**	**0**	**0**	**0**	**0**	**0**	**0**

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Combinations: synthetic call

A + B (long stock + long put)

Spot price, St	10	20	30	40	50	60	70	80	90	100
Strike price	50	50	50	50	50	50	50	50	50	50
Spot price	10	20	30	40	50	60	70	80	90	100
Profit, stock	-40	-30	-20	-10	0	10	20	30	40	50
Profit, put	40	30	20	10	0	0	0	0	0	0
Profit portfolio	**0**	**0**	**0**	**0**	**0**	**10**	**20**	**30**	**40**	**50**

Compare this to a long call position

C. Call (long)

Spot price, St	10	20	30	40	50	60	70	80	90	100
Strike price	50	50	50	50	50	50	50	50	50	50
Spot price	10	20	30	40	50	60	70	80	90	100
Profit call	**0**	**0**	**0**	**0**	**0**	**10**	**20**	**30**	**40**	**50**

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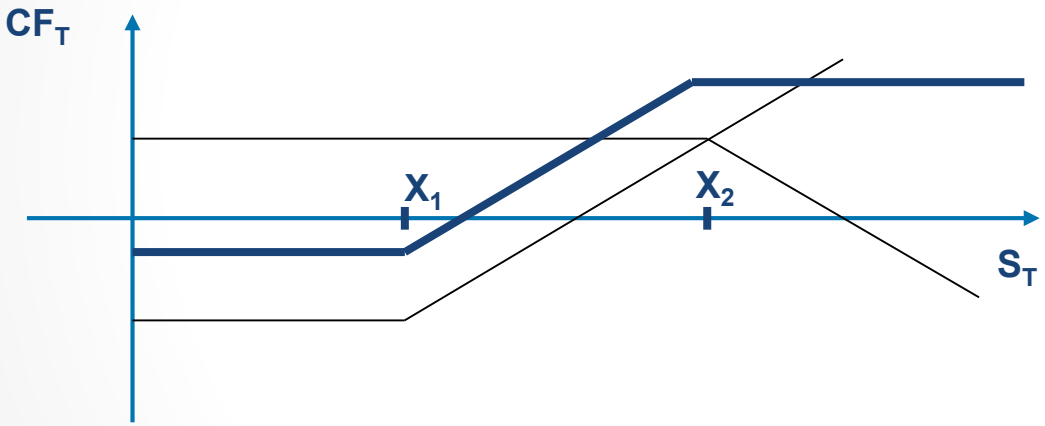
Bull spread



- The price of a call decreases with increasing strike. Net investment.

- Market view: believe that the price of the underlying will increase

- Upside and downside is limited

- Cheaper portfolio than just hedging the downside

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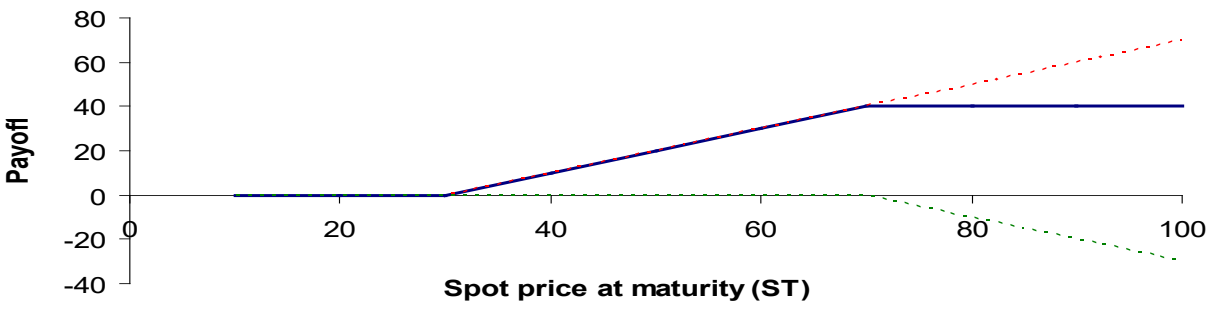
Composition

- Long call, X1 = 30
- Short call, X2 = 70
- Spot price = 10, 20, ..., 100



Spot price, St	10	20	30	40	50	60	70	80	90	100
Strike price, X1	30	30	30	30	30	30	30	30	30	30
Profit long call, X1	0	0	0	10	20	30	40	50	60	70
Strike price, X2	70	70	70	70	70	70	70	70	70	70
Profit short call, X2	0	0	0	0	0	0	0	-10	-20	-30
Profit portfolio	**0**	**0**	**0**	**10**	**20**	**30**	**40**	**40**	**40**	**40**

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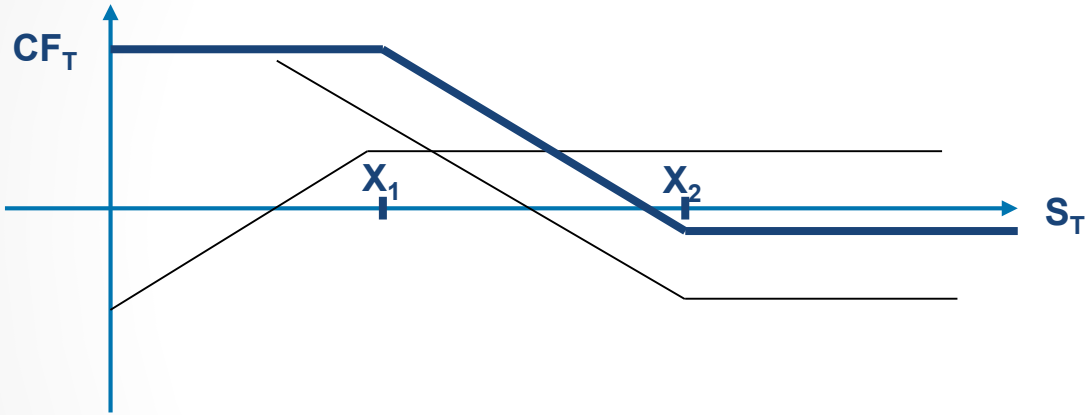
Bear spread



Short put with strike X_1 + Long put with strike X_2

- The price of a put increases with decreasing strike price. Net initial payment

- Market view: believe the price of the underlying will dectrease

- Limited upside and downside

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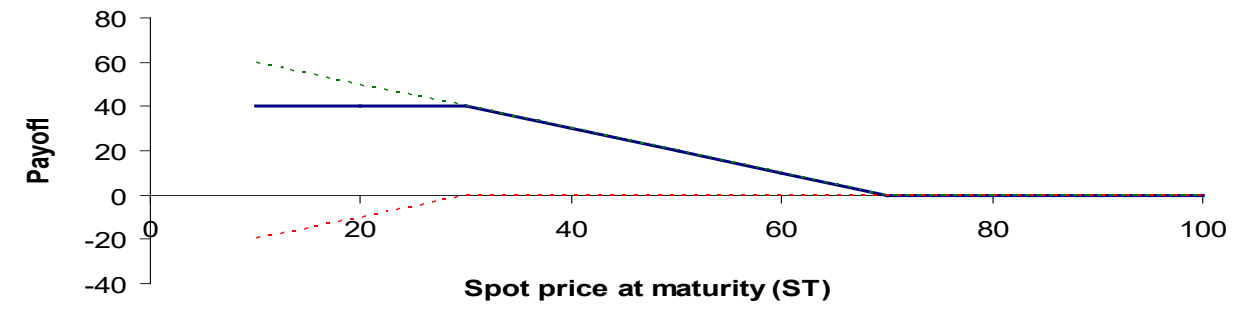
Composition

- short put, X1 = 30
- long put, X2 = 70
- Spot price = 10, 20, ..., 100



Spot price, St	10	20	30	40	50	60	70	80	90	100
Strike price, X1	30	30	30	30	30	30	30	30	30	30
Profit short put, X1	-20	-10	0	0	0	0	0	0	0	0
Strike price, X2	70	70	70	70	70	70	70	70	70	70
Profit long put, X2	60	50	40	30	20	10	0	0	0	0
Profit portfolio	**40**	**40**	**40**	**30**	**20**	**10**	**0**	**0**	**0**	**0**

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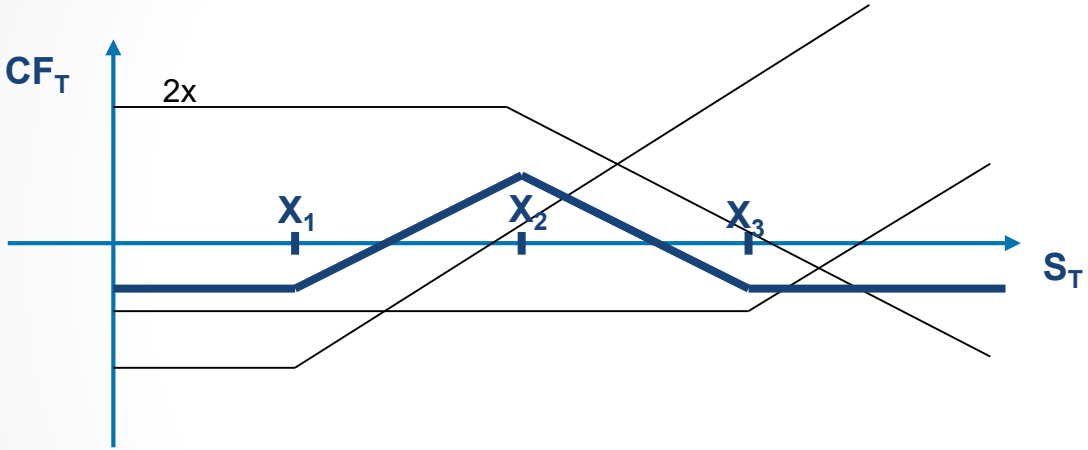
Butterfly spread



Long call with strike X_1 + (2x) short calls with strike X_2 + long call with strike X_3

- Option with 3 strikes
- Profit if S_T is close to strike X_2
- A small loss when the prices of the underlying moves a lot
- Market view: Don't believe in large price movements
- A small initial investment

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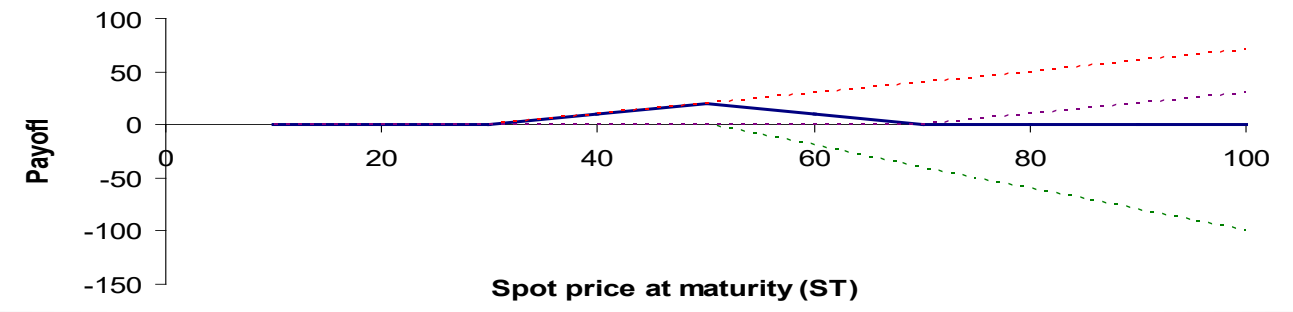
Composition

- long call, X1 = 30
- 2 x short call, X2 = 50
- long call, X3 = 70
- Spot price = 10, 20, ..., 100



Spot price, St	10	20	30	40	50	60	70	80	90	100
Strike price, X1	30	30	30	30	30	30	30	30	30	30
Profit long call, X1	0	0	0	10	20	30	40	50	60	70
Strike price, X2	50	50	50	50	50	50	50	50	50	50
2 x Profit short call, X2	0	0	0	0	0	-20	-40	-60	-80	-100
Strike price, X3	70	70	70	70	70	70	70	70	70	70
Profit long call, X3	0	0	0	0	0	0	0	10	20	30
Profit portfolio	**0**	**0**	**0**	**10**	**20**	**10**	**0**	**0**	**0**	**0**

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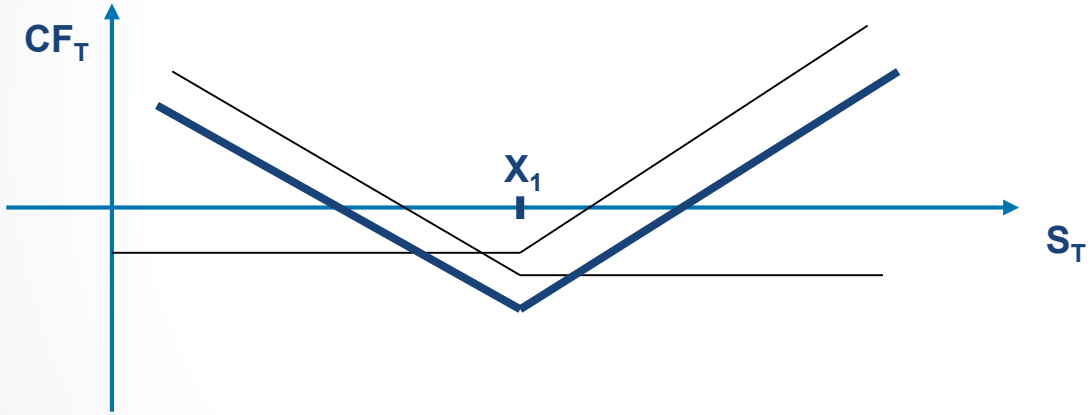
Speculation in volatility

- Straddle



Long call and long put with same strike price

- Market view: an investor expects a large price movement (high volatility), but does not know in which direction the price will move

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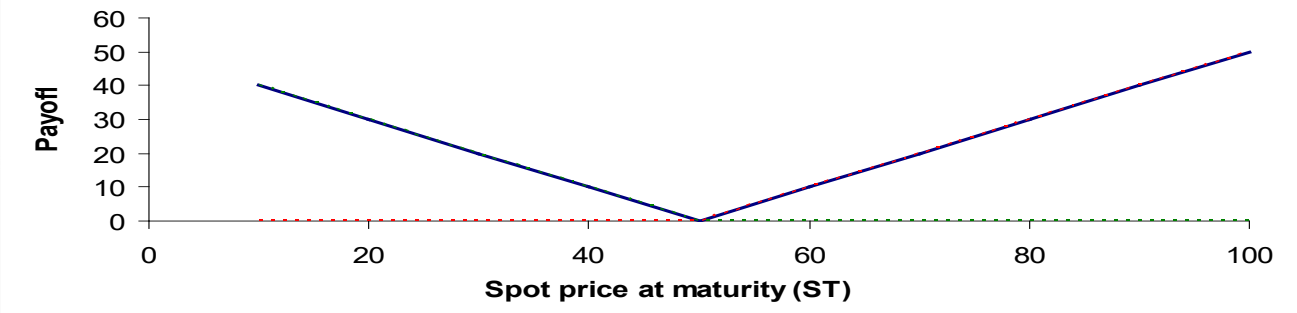
Composition

- long put, X1 = 50
- long call, X1 = 50
- Spot price = 10, 20, ..., 100



Spot price, St	10	20	30	40	50	60	70	80	90	100
Strike price, X1	50	50	50	50	50	50	50	50	50	50
Profit long call, X1	0	0	0	0	0	10	20	30	40	50
Profit long put, X1	40	30	20	10	0	0	0	0	0	0
Profit portfolio	**40**	**30**	**20**	**10**	**0**	**10**	**20**	**30**	**40**	**50**

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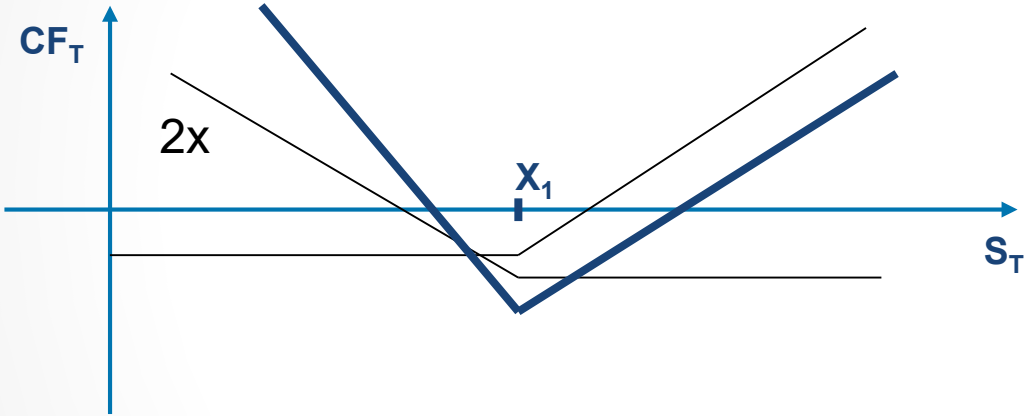
Strip



Long call og 2x long put med samme strike

- Market view: an investor expects a large price movement (high volatility), but does not know in which direction the price will move
- However, believes that market is more likely to move down than up

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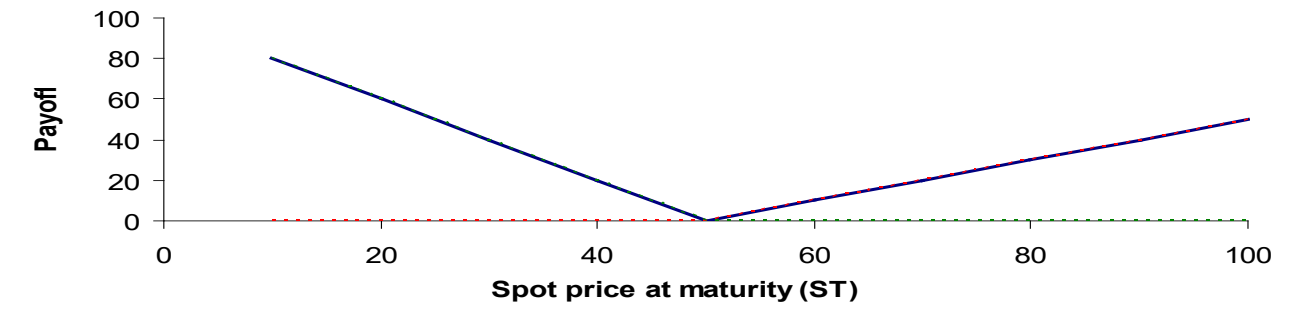
Composition

- 2x long put, X1 = 50
- long call, X1 = 50
- Spot price = 10, 20, ..., 100



Spot price, St	10	20	30	40	50	60	70	80	90	100
Strike price, X1	50	50	50	50	50	50	50	50	50	50
Profit long call, X1	0	0	0	0	0	10	20	30	40	50
2 x Profit long put, X1	80	60	40	20	0	0	0	0	0	0
Profit portfolio	**80**	**60**	**40**	**20**	**0**	**10**	**20**	**30**	**40**	**50**

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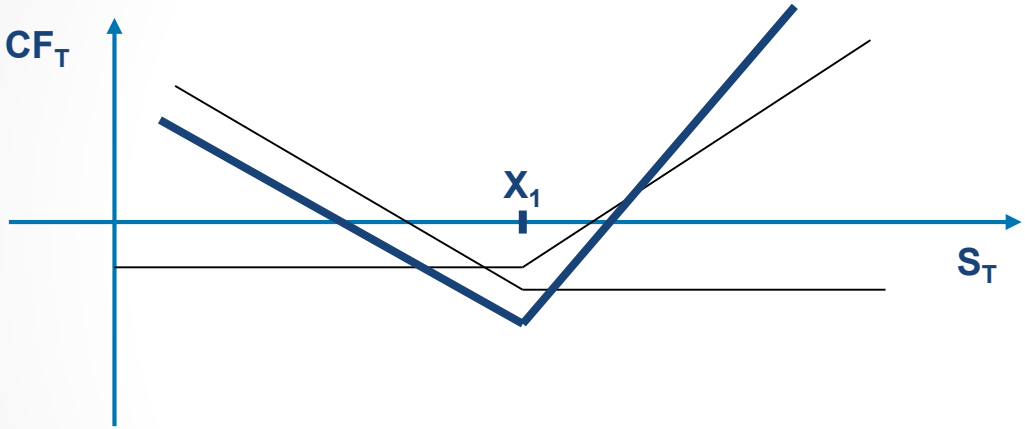
Strap



2x Long call and 1 long put with same strike

- Market view: an investor expects a large price movement (high volatility), but does not know in which direction the price will move
- However, believes that market is more likely to move up than down

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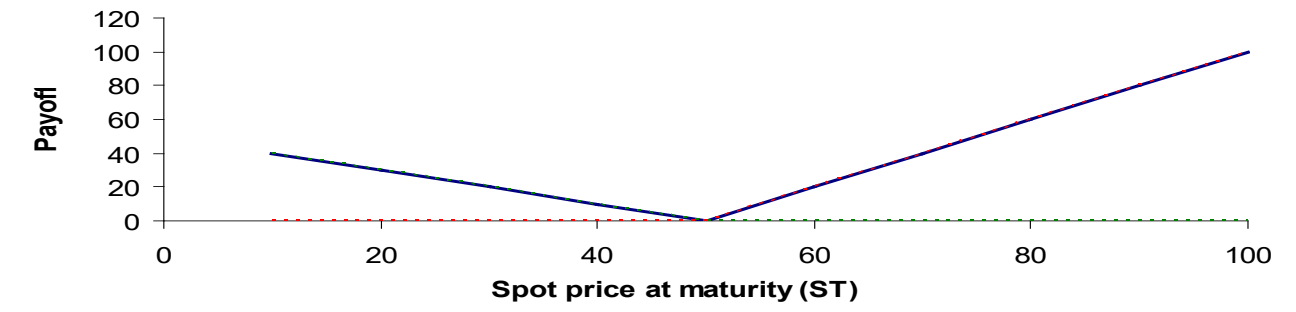
Composition

- long put, X1 = 50
- 2x long call, X1 = 50
- Spot price = 10, 20, ..., 100



Spot price, St	10	20	30	40	50	60	70	80	90	100
Strike price, X1	50	50	50	50	50	50	50	50	50	50
2x Profit long call, X1	0	0	0	0	0	20	40	60	80	100
Profit long put, X1	40	30	20	10	0	0	0	0	0	0
Profit portfolio	**40**	**30**	**20**	**10**	**0**	**20**	**40**	**60**	**80**	**100**

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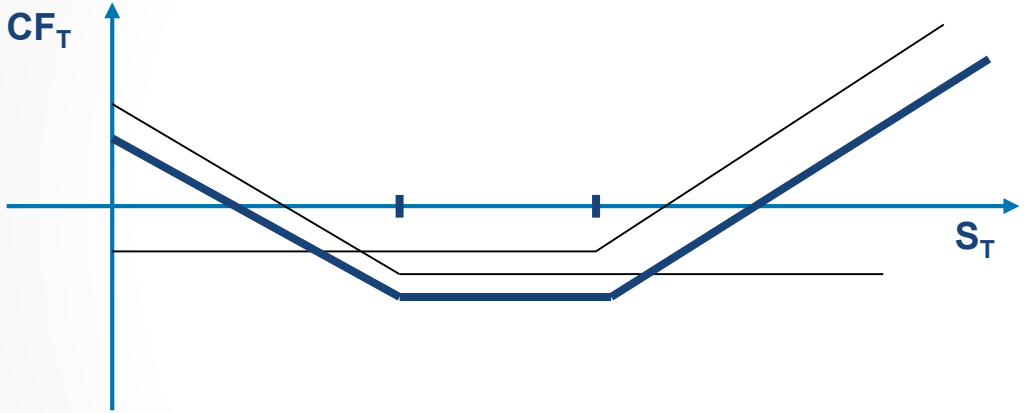
Strangle



Long call and long put with different strike prices

- Market view: an investor expects a large price movement (high volatility), but does not know in which direction the price will move
- Believes that the price of the underlying will move more (even higher volatility) than with a straddle

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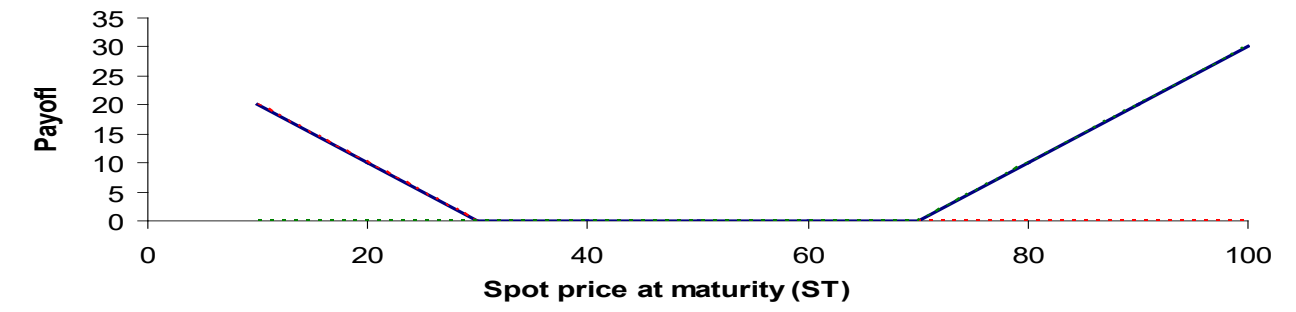
Composition

- long put, X1 = 30
- 2x long call, X1 = 70
- Spot price = 10, 20, ..., 100



Spot price, St	10	20	30	40	50	60	70	80	90	100
Strike price, X1	30	30	30	30	30	30	30	30	30	30
Profit long put, X1	20	10	0	0	0	0	0	0	0	0
Strike price, X2	70	70	70	70	70	70	70	70	70	70
Profit long call, X2	0	0	0	0	0	0	0	10	20	30
Profit portfolio	**20**	**10**	**0**	**0**	**0**	**0**	**0**	**10**	**20**	**30**

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Calender spread

- Calender spread
  - options that have the same strike price, but different maturities
  - Can be created by selling a call option with a certain strike price and buying a longer-maturity call options with the same strike price

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Exercises

- Create a Bull spread using put options
- Create a Bear spread using call options

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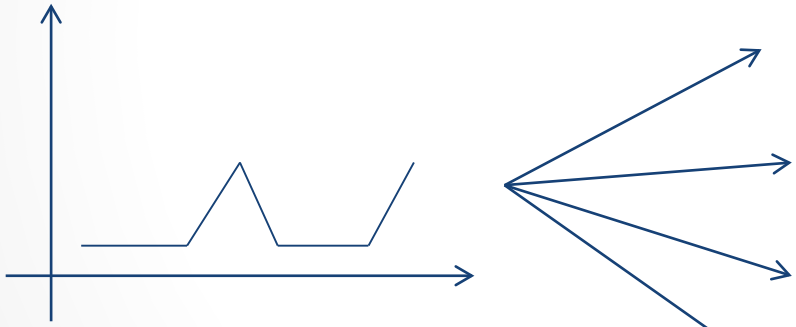
Why learn about option portfolios and strategies?

- Gives insight into construction of option portfolios
- Can give insight into structured derivative products (including valuation)



Structure product

Option 1 → Value

Option 2 → Value

Option 3 → Value

Bond → Value

= Value Structure product

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Relevant literature

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