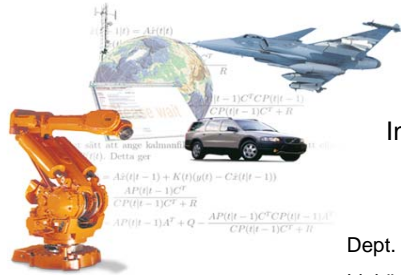


## Lecture 1



### Introduction to Financial Modeling

Dept. Of Electrical Engineering  
Linköping University, Sweden

## Structure of the course

- Introduction to financial markets, basics of equities, commodities, foreign-exchanges, forward and futures. **October 29<sup>th</sup>** .
- Options, payoff diagram, put-call parity, options strategy . **November 1<sup>st</sup>** .
- Poisson process and Brownian motion, introduction to stochastic differential equations, Ito calculus, Wiener, Orstein -Uhlenbeck, Langevin equation, introduction to martingales, examples of common models used in finance, risk neutral pricing, Fynman-Kac formula. **November 5<sup>th</sup>** .
- Black-Scholes model and the Greek letters. **November 8<sup>th</sup>**.
- Volatility problem ,implied volatility , smile dynamic, leverage effect, heteroskedasticity, introduction to Garch and stochastic volatility models. **November 19<sup>th</sup>** .
- Inference problems. **November 22<sup>nd</sup>** .
- System identification in finance, parametric, semi/non parametric, maximum likelihood, EM. **November 26<sup>th</sup>** .
- Some advanced topics and course summary. **November 29<sup>th</sup>**.

## Evaluation

- Homework (2 or 3) . No exam.
- Mini project.

The schedule for questions : ???

## Outline

- Part A  
Short introduction to financial system and  
Financial modeling
- Part B  
  
Forward & futures contracts

## Financial system

In addition to lenders and borrowers, the financial system has 3 components:

- Financial markets, where transactions take place;
- Financial intermediaries, who facilitate the transactions;
- Regulators of financial activities who try to make sure that everyone is playing fair.

## Financial Markets

A **financial market** is a market in which people and entities can trade financial securities, commodities, and other fungible items of value at low transaction costs and prices that reflect supply and demand.

**Security:** Financial instruments secured by physical assets.

**Commodity:** Any marketable item produced to satisfy needs or wants (petroleum and copper are examples of commodities).

▪ If many commodities are traded it is a general market, if there is only one commodity traded it is called a specialized market.

## Types of financial markets

- Capital markets (Stock and Bonds)
- Commodity markets
- Money markets
- Derivative markets
- Future markets
- Insurance markets
- Foreign exchange markets

## Functions of a financial market

- Raising of capital (capital markets)
- Transfer of risk (derivative markets)
- Price discovery
- Global transactions with integration of financial markets
- Transfer of liquidity (money markets)
- International trade

## Financial intermediaries

The role of financial intermediaries is to create more favorable transaction terms than could be realized by lenders/investors/borrowers dealing directly in the financial market. Financial intermediaries accomplish this in a 2-step process:

- Obtaining funds from lenders or investors.
- Lending or investing the funds that they borrow to those who need funds.

This process allows to transform financial assets that are less desirable into other financial assets.

## Regulating financial activities

The degree of regulation varies from country to country, but usually takes one of four forms:

- Disclosure regulation.
- Financial activity regulation.
- Regulation of financial institutions.
- Regulation of foreign participants.

## About securities..

Securities are categorized into:

- Debt securities (banknotes, bonds and debentures).
- Equity securities, (common stocks).
- Derivative contracts (forwards, futures, options and swaps).

The company or the entity issuing the security is called the **issuer**.

Securities may be represented by a certificate or, more typically, “non-certificated”, that is in electronic or “book entry” only form

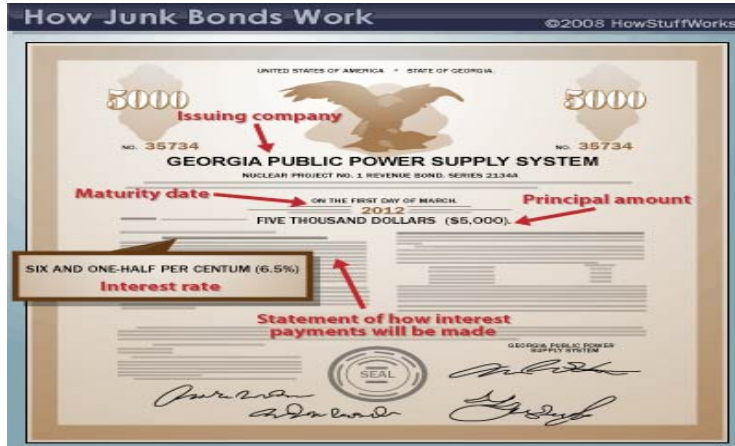
Securities are traditionally divided into debt securities and equities.

**Debt.** These may be called debentures, bonds, deposits, notes or commercial paper depending on their maturity and certain other characteristics.

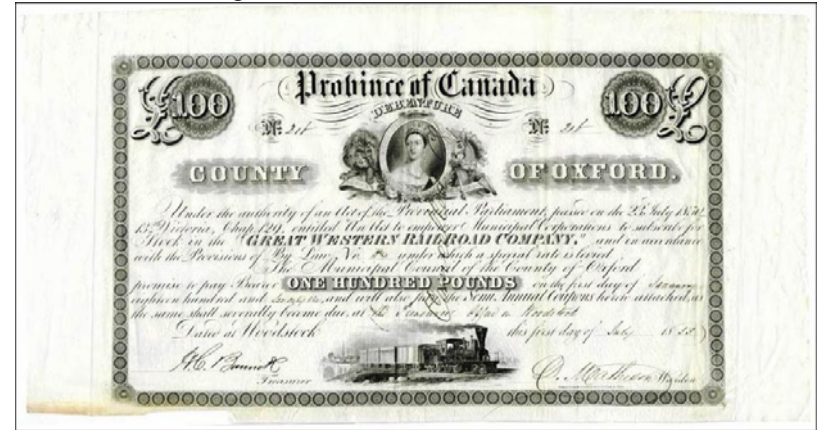
**Equity.** Is a share of equity interest in an entity such as the capital stock of a company, trust or partnership. The most common form of equity interest is common stock.

## Some definitions related...

**Bonds.** Instruments of indebtedness of the issuer to the holder..



**Debenture.** A debenture is a document that either creates a debt or acknowledges it, and it is a debt without collateral.



**Exchange.** An exchange or bourse is a highly organized market where tradable securities, commodities, foreign exchange, futures, and options contracts are sold and bought.

Exchanges bring together brokers and dealers who buy and sell these objects, that can be sold either through the exchange, typically with the benefit of a clearinghouse to cover defaults, or over-the-counter (OTC), where there is typically less protection against counterparty risk from clearinghouses.



Exchanges can be subdivided:

- ◆ By objects sold:
  - ✓ Stock exchange or securities exchange
  - ✓ Commodities exchange
  - ✓ Foreign exchange market
  
- ◆ By type of trade:
  - ✓ Classical exchange – for spot trades
  - ✓ Futures exchange or futures and options exchange –for derivatives





**Over-the-counter (OTC).** Or off-exchange trading is to trade financial instruments such as stocks, bonds, commodities or derivatives directly between two parties.

It is contrasted with exchange trading, which occurs via facilities constructed for the purpose of trading, such as futures or stock exchanges.



## Derivatives

### Derivatives

A derivative is a market instrument such that its value is derived from, the value of another (underlying) asset.

Type: futures, forwards, options, .. (will be explained later)

The underlying assets include stocks, currencies, interest rates, commodities, debt instruments, electricity, insurance payouts, the weather, etc

Example: European put option

Derivatives play a key role in transferring risks in the economy



## Financial modeling

- Assets have uncertain future values:
- See e.g., Yahoo finance , Google finance...
- Nobody cares if worst possible future value is more than today's value
- Reality: asset may return less – risk !!
- Probabilistic model



## Financial modeling

Louis Bachelier (1870-1946)

- founder of modern mathematical finance
- apply stochastic processes to evaluate stock options
- His PhD thesis *The Theory of Speculation* (1900) covered the study of finance with the use of Brownian motion



(source: Wikipedia)

## Financial modeling

Objective of the financial model

- building basic conceptual understanding
- helping in understanding 'risk exposure'
- translating to practices

Model generally uses information available publicly

Models are built using empirical evidence (aka 'stylized facts')

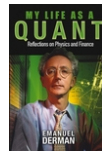
Modeling difficulty

Model dynamics may mute to new one hitherto unforeseen

"Financial theory has tried hard to emulate the style and elegance of physics in order to discover its own laws. But markets are made of people, who are influenced by events, by their ephemeral feelings about events and by their expectations of other people's feelings. The truth is that there are no fundamental laws in finance."

## Financial modeling

Modeler's Hippocratic Oath:



- I will remember that I didn't make the world, and it doesn't satisfy my equations.
- Though I will use models boldly to estimate value, I will not be overly impressed by mathematics.
- I will never sacrifice reality for elegance without explaining why I have done so.
- Nor will I give the people who use my model false comfort about its accuracy. Instead, I will make explicit its assumptions and oversights.
- I understand that my work may have enormous effects on society and the economy, many of them beyond my comprehension.

## Some basic concepts

Central theme: the concept of **no arbitrage**

- Arbitrage : trading strategy taking advantage of two or more securities being mispriced relatively to each other
- Locking in a riskless profit by entering into transactions simultaneously in two or more different markets
- a portfolio is an arbitrage portfolio if it is self financing
  - (a) value of portfolio today,  $V(t) = 0$ ,
  - (b)  $P(v(T) \geq 0) = 1$  where  $(T > t)$
  - (c)  $P(v(T) > 0) > 0$

## Illustrative example of arbitrage ( page 15, Hull )

- A stock traded on both NYSE and LSE
  - Current price 140 \$ / 100 £
  - Exchange rate : 1.43 \$ per £
  - Strategy : simultaneously buy 100 shares in NYSE and sell them in LSE.
- 
- Risk free profit :  $100 \times [1.43 \times 100 - 140] \$ = \$ 300$
  - Assumption: no transaction cost, tax, etc

### *Price Convergence :*

ephemeral phenomenon, market quickly spot and opportunity vanishes



## Common assumption: 'efficient market'

- absence of arbitrage
  - market efficiency works only if somebody does not believe in it !!
  - price encodes all publicly available information.
  -
- 
- Role of mathematics: not to predict but to relate the movement of price of one asset to others. This price movement are driven by information arriving in the market. This is unknown until it arrives. Treat it as random.

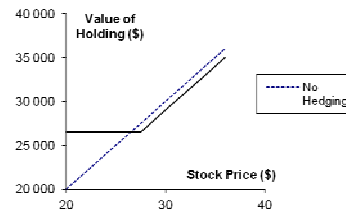


## The concept of Hedging

- Hedging : the process to reduce risk by taking positions in different financial instruments

Example : hedging using put options  
(pg. 12, Hull)

- 1000 shares
- 10 option contracts with strike \$ 27.50
- expiry: 2 months after this date
- quoted option price : \$1



## Market participants:

- Hedger: uses available market instruments to reduce risks
- Speculator: uses market instruments to increase returns (so, risk!)
- Arbitrageur : tries to spot discrepancies in pricing ( selling one and buying the same at a different price elsewhere at the same time, tries to pocket profit without risks!)

Bank : Speculator and Arbitrageur

Private investor: speculator

Companies : hedger (try to minimize risk exposure)



## Liquidity:

we can buy or sell at any time as much as wish at the market price. Due to presence of different market participants, investor is not forced to wait for a suitable counterparty.

## Short selling /Shorting:

one can have negative assets by selling assets one does not hold. Some restrictions on sorting in the market.

- At some stage one must buy the securities so they can be replaced in the account of the client
- There may be a small fee for borrowing the securities



## ▪ Part B



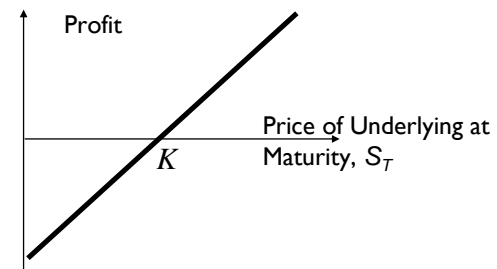
## Forward contracts

- Agreement between two (private) parties to buy or sell an asset for a certain price at a certain time
- No payment until delivery date, but obligation to buy/sell the asset
- Amount paid at delivery : delivery price (DP)
  - set at the beginning of contract (Forward price)
- Forward price leads to zero Initial value for the contract
- Value at maturity is difference between DP and spot price of underlying asset



## Profit from a Long Forward Position

( $K$  = agreed delivery price = forward price at time contract is placed)





## Determining forward price

- $S_0$ : Spot price today
- $F_0$ : Forward price today
- $T$ : Time until delivery date
- $r$ : Risk-free interest rate for maturity  $T$

Using principle of no arbitrage,  $F_0 = S_0 e^{rT}$

If  $F_0 > S_0 e^{rT}$ , buy asset & short forward contract

If  $F_0 < S_0 e^{rT}$ , short asset & long forward contract

Note: linear relation between spot price and forward price !

## Futures contract

- Agreement to buy or sell an asset for a certain price at a certain time
- Futures contract is traded through exchange (whereas a forward contract is traded OTC)
- Standardized terms of contracts
  - time, place, quality
- Profit/loss settled daily from one party to other
  - value over entire life is zero
- Futures price may vary on each day, but at maturity, equals the underlying spot
- Closing out a futures position involves entering into an offsetting trade
- Most contracts are closed out before maturity

## Margins

- To reduce the likelihood of credit default by any party, exchanges require both parties to maintain accounts in cash or marketable securities, known as margins.
- The balance in the margin account is adjusted to reflect daily settlement
- Two forms
  - initial margin : amount deposited at the contract initiation
  - maintenance margin : to maintain a minimum level

## Difference between forward and futures contracts

Forwards	Futures
private (OTC)	exchange traded
non standard	standard specifications
usually single delivery date	range of delivery dates
settle at maturity	daily settlement
settlement usually occurs	contracts usually closed out prior to maturity
credit risk present	virtually no credit risk