Entrepreneurial Risk
Summary

April 8, 2020

Chapter 1

Introduction

Types of risk:

- **Industrial risks**
  - change in technology, productivity, prices
  - false estimates of the rated capacity
  - time needed for the construction and running-in periods, political, social, and business enviroment
- **Operational risks**
  - Lack of entrepreneurship skills
  - Poor understanding of market dynamics
  - Poorly available consultancy services and information systems
  - Poor understanding of how to prepare a business plan
  - Natural risks (energy companies, constructor companies,...)
- **Market risks**
  - Unforeseeable inflation and exchange rates change
  - Customer behaviors to buy foreign goods
  - Inadequate infrastructure
  - Shrinking market because of foreign competitors
  - Defaulting or insolvency, Credit risks
- **Cultural risks**
- **Natural risks** (Hailstorm, earthquakes, hurricanes, dry seasons, and other natural hazards)
- **Economic and political risks**

Formal Representation of Risk: Risk is commonly measured as a pair of the probability of occurence of an event, and the outcomes or consequences associated with the event's occurrence

$$Risk = [(p_1, c_1), (p_2, c_2), \ldots, (p_n, c_n)]$$

Technical Terms:

- **Hazard**
  - A hazard is an act or phenomenon posing potential harm to some person or thing i.e a source of harm and its potential consequences
  - Hazards need to be identified and considered in projects lifecycle analyses since they could pose threat and could lead to project failures
- **Uncertainty**
  - Aleatoric uncertainty: due to variability inherent in the phenomenon under consideration
  - Epistemic uncertainty: lack of knowledge, important missing mechanisms

$$\text{Risk} = \text{Uncertainty} + \text{Damage}$$
$$\text{Risk} = \text{Hazard/Safeguard}$$

- **Reliability**
- **Event Consequences**
- **Performance**

- **Risk-based Technology**

  Risk Assessment consists of:

  - Hazard identification
  - Event probability assessment
  - Consequence assessment

  Risk Control: Require the definition of acceptable and comparative evaluation through monitoring and decision analysis, also includes failure prevention and consequence mitigation

  Risk communication: Involves the perceptions of risk and depends on the audience targeted. Hence it is classified into:

  - Risk communication to the media
  - To the public
  - To the engineering community

  Human Errors: Human errors are unwanted circumstances caused by humans that result in deviation from expected norms that place systems at risk. It is important to identify the relevant errors to make accurate risk assessments. Human error identification techniques should provide a comprehensive structure for determining significant human errors within the system.

  Human Error Modelling: Currently there is no consensus on how to model humans reliably.

  Human Error Quantification: Still a developing science requiring understanding of human performance, cognitive processing, and human perceptions.

Chapter 2

Start-ups and Investment in Innovation

Difference between Private Equity and Venture Capital:

Private Equity is:

- Financing mainly used to buy mature well-established companies and get full control (100% of company)
- Always a combination of debt and equity (shares)
- Value created through streamlining of operations, cost cutting, consolidation ...
- Strong focus on cash flow to pay off debt, companies are highly leveraged (much debt relative to equity). Leverage increases risk profile but also the potential returns
- Large deal sizes (hundreds of millions)

Venture Capital is:

- Financing mainly given to startup companies and small businesses
- Value created through growth
- Growth expected from innovation, disruptive technology, new product, business plan
- Very high risk profile, no cash flow but cash burn (that is where the money is used for)
- Company can only finance through equity, often risk profile is too high to get debt financing
- Smaller deal sizes (millions)
- no full control (50% or less)

Investors Viewpoint: Investors want to manage their risk with preference shares and by gaining as much control as possible on the company through shareholder agreements, voting rights, board membership, anti-dilution clauses ... The pay-off is highly skewed, there are many losers and a few big winners, hence Investors must be detached from individual companies and look at the whole portfolio. This is not aligned with the Entrepreneurs viewpoint

Preference Shares:

- If a company goes bankrupt, during the liquidation the investor is payed first
- If a company is sold investors recieve payment (including compounded interest) before common shareholders (founders,...)

Percieved versus Actual Risk: Two kinds of bias were identified:

1. Tendency to overestimate small frequencies and underestimate larger ones
2. Tendency to exagerate the frequency of some specific causes and to underestimate the frequency of others

Individuals assess losses and gains in an asymmetric way i.e "Losses loom larger than gains"

Intrinsic: Focus on passion

Extrinsic: Focus on success i.e money promotion etc.

Challenges of exploration:

- tolerance of ambiguity
- patience : learning-by-doing/trial and error
- luck/serendipity
- persistence / diligence
- intuition

	Entrepreneur/Founder	Investor
Motivation	Intrinsic	Extrinsic
Goal	Realize a dream	Make money
Horizon	Not relevant	Medium term (3 to 7 years)
Risk	All in	Portfolio view, highly skewed payoff with few very successful winners but mostly losers
Viewpoint	Stakeholders (employees, customers, community, suppliers ...)	Shareholders
Skin in the game	own money and resources	other people's money
Role	Exploration	Exploitation
Involvement	Personal, company is like a child	Detached, rational, strategic

Figure 2.1: Viewpoints of Entrepreneurs and Investors

It is a high risk endeavor, where the payoff is almost impossible to estimate. Disruptive innovations are initially too small to meet the ROI-targets of large established firms. However they steadily work their way up eventually capitalizing on a crucial firstmover advantage against large, less nimble, market leaders.

Creativity or Rational Criticism: It is important to find the right balance between creativity/exploration and rationalism/exploitation. When the governance of a company is well-designed and the power between Entrepreneurs and investors is well-balanced you get the best of both worlds: The long-term perspective, personal commitment and explorative approach of the Founder, balanced with the detachment, rational, efficient, technical and financial approach of the Investor.

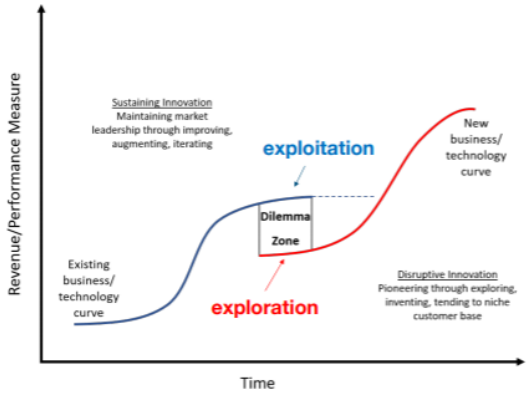


Figure 2.2: Pre/Post-Money

NDA - Non Disclosure Agreement: This is a legal contract that outlines the use of confidential material, knowledge and information that the parties wish to exchange. Issues addressed in an NDA:

- The definition of what is confidential
- Exclusions
- Time period of confidentiality
- Description of what must be done with the confidential material upon agreement ending (duty to return or destroy)

After the NDA is signed by both parties, access is given to the data room.

LOI - Letter of Intent: After a first check of the data room, the investors will produce a term sheet or LOI this,

- outlines an agreement that two or more parties expect to make

- Term Sheet(TS) and LOI are very similar in content but TS is structured as a list (table format), whereas LOI is in the form of a letter
- Written before the execution of a formal and binding contract, most of the listed agreements are not legally binding

Exclusivity:

- Legally binding clause of the LOI or TS
- Caveat: Transfers a lot of control to the investor, they will be the only party taking the next step in the process and can take advantage of the 'sunk cost effect'. When given exclusivity, time is on the side of the investor
- The investor can put you under pressure, test your tenacity and patience, try to decrease the valuation of the company. When you give exclusivity you cancel out any competition for the investor, this will make them dominant.

Due Diligence: After the Term Sheet and/or LOI are signed the Due Diligence process is started. Now external advisors enter the arena:

- Business lawyers review all the contracts in the data room
- IP lawyers will study the strengths of the patents of the company and the 'freedom to operate' (with respect to the patents of other companies)
- External Auditor will validate the accounting, financial statements, balance sheet, taxes
- Tech-consultant may analyze the product development and the strength and relevance of the tech with respect to other solutions

The investors themselves will:

- Reference check clients, founders, key personnel
- Analyze the commercial viability of the product and the sales process and tools
- Study the quality of the sales pipeline
- make their own forecast of future sales and of future cashflows

Based on the results of the due diligence, the investors will challenge the business plan:

- Create base-case and worst-case scenarios of cash burn
- Confirm if the founders are asking for too much or too little
- Assess the risk of their investment
- Set management goals
- Find the gaps i.e where the company needs further support and make their own valuation of the company

Chapter 3

Introduction to company valuation

Reports for a company:

- balance sheet
- profit and loss acount
- cash flow statement

Enterprise Value vs. Equity:

- **Enterprise Value** is the price to acquire the whole company, the shares, debt but also receiving the cash.
- **Equity Value** is the price to acquire only the shares of a company
- EnterpriseValue(EV) = Equity + Debt - Cash

LLC in Switzerland To set up a LLC in Switzerland we need to pay 20k CHF out of pocket

ASSETS = LIABILITIES + EQUITY

Looking at equity in a balance sheet is one way to assess the value of the company. At the beginning the company is only worth the amount that we have put into it (nothing has happened yet).

Balance Sheet: Table keeping track of Assets, Liabilities and equity. The balance sheet is dynamic i.e it changes every year. Each year, depreciation of assets, equity increases by the profit amount, liabilities decrease if paid off.

Return on Equity: A measure of profibility of the company. The gain over the past year.

$$ROE = \frac{EQUITY}{PROFIT}$$

Leverage: Measures how much money you put in the company yourself to how much money you attract. Leverage increases your risk proportionally. The larger the business is, the higher the losses can be. Increasing the business with debt, without increasing the equity buffer proportionally, you will have a higher ROE but also a much higher risk of insolvency (not being able to service the larger amount of debt). When continuing to accumulate losses, at some time your full equity buff will be consumed. Because of the cash you burn, debts become higher than your assets, your company has "negative equity" this is a sign of future insolvency. Insolvency and negative equity may lead to debt restructuring or bankruptcy. You need the right balance between debt and equity (1/1, 3/2 max 2/1 debt/equity).

$$LEVERAGE = \frac{LIABILITIES}{EQUITY}$$

Ways to evaluate a company:

- A company's value can be deduced from its balance sheet. This is a very static approach. It takes a snapshot of the equity in the balance sheet and does not consider how this was acquired (one year, ten years?) A company is a "process" that generates profit (or loss) based on people, strategy and stuff(assets,tech,...). Hence it makes sense to use metrics from the P&L to value the company.

Banking: E.g Taxi business: When starting the business, if you make losses your equity buffer goes down, if you make profits the buffer will increase. For banks, assets (bonds, stocks, loans(largest asset),...) may lose value due to systemic market events,and equity may decrease due to accumulated losses. Banks operate using large leverage ratios (In 2007 40/1 hence a drop of their assets by 2.5% would leave them with a negative equity). The government calculates how much equity a bank must have. The banking system is closely knitted hence if Bank A collapses then bank B will also get in trouble and they cannot provide loans to companies. Resulting in the whole economic system collapsing. Too much leverage in the system may make it very vulnerable and susceptible to systemic shocks.

Profit and Loss:

- **Revenue**(sales): is the top line i.e how much money is generated by the business per year
- **Costs of goods sold** (COGS): costs of material and labour to run the business
- **Gross Margin**:

$$\text{Gross Margin} = \text{Revenue} - \text{COGS}$$

- **Operating Expenses** (OPEX): Remaining costs that are not included in COGS (costs of office and equipment and other overhead e.g depreciation of taxis in taxi business)
- **Earnings Before Interest and Taxes** (EBIT): Operating profit of the company

$$\text{EBIT} = \text{Gross Margin} - \text{OPEX}$$

(6% is good for a small company. It is the part of sales that belong to the owner and debt owner)

- **Earnings Before Interest,Taxes, Depreciation and Amortization** (EBITDA):

$$\text{EBITDA} = \text{EBIT} + \text{D\&A}$$

- **Earnings Before Taxes** (EBT):

$$\text{EBT} = \text{EBIT} - \text{Interests paid}$$

- **Net Profit**: part of sales that belong to the owner.

$$\text{Net Profit} = \text{EBIT} - \text{Interests paid} - \text{taxes}$$

- **Margin Sensitivity**: How sensitive is the Net profit to fluctuations in the cost

Relative Valuation: Do not compare companies based on the stock price. Look at companies in the same field and compare their performance in the market. Find a normalized share price. An important metric is $\frac{price}{earnings}$ i.e price of the company divided by the earnings per year. Public companies are more expensive than private companies because private companies are less liquid and hence cannot be sold as easily (Liquidity premium)

Valuation Multiples:

- **P/E** ratio: Calculate a company's share price (Equity) from its earnings (net profit)
- **EV/EBITDA** ratio: Calculate a company's Enterprise Value from its EBITDA
- **EV/EBIT** ratio: Calculate a company's Enterprise Value from its EBIT

Components of Cash Flow:

- **Operating Activities:** e.g Income - living costs
- **Investing Activities:** e.g Car, House
- **Financing Activities:** e.g Bank Loan to buy Car, House

Operating Activities Cash Flow:

$$OperatingCashFlow = NetIncome + NonCashExpenses - IncreaseInWorkingCapital$$

- δ WC = Change in Accounts Receivable + Change in Inventory - Change in Accounts payable
- **Accounts receivable** = Sum of all invoices sent out to customers that have not paid yet
- **Accounts payable** = Sum of all invoices recieved from vendors that you have not paid yet

Investing Activities Cash Flow:

$$InvestmentActivitiesCashFlow = (Purchase/Sale)\ LongTermAssets + (Purchase/Sale)Businesses + (Purchase/Sale)MarketableSecurities$$

Financing Activities Cash Flow:

$$FinancingActivitiesCashFlow = (Issue/Repurchase)Equity + (Issue/Repurchase)Debt + DividendPayments\&OtherItems$$

Risk of fast growth: As a startup when you grow very fast, your working capital can also increase very quickly because:

- You have to pay vendors early (in advance) because they do not trust you (being a young company) and otherwise they will not supply
- You do not get paid by clients because they have strong negotiating power
- You have to increase your inventory

$\Rightarrow$ You can get in serious liquidity problems and even go bankrupt because you grow too fast

Time value of money:

- FV = Future Value
- PV = present Value
- n = number of periods in years
- r = rate of return or discount rate or interest rate or growth per period

$$FV = PV \cdot (1+r)^n$$

Bond: A bond is a loan that you can trade in the market i.e a liquid loan. A loan pays you a coupon which pays you a percentage of the value you bought it at:

$$BondPrice = \frac{C}{1+i} + \frac{C}{(1+i)^2} + \cdots + \frac{C}{(1+i)^n} + \frac{M}{(1+i)^n}$$

- C = coupon payment
- n = number of payments
- i = interest rate, or required yield
- M = value at maturity or par value

⇒ The same principle can be applied to value a company, this is called Discounted Cash Flow Valuation

Discounted Cash Flow Valuation:

$$PV = \frac{CF_1}{(1+r)^1} + \frac{CF_2}{(1+r)^2} + \frac{CF_3}{(1+r)^3} \cdots \frac{CF_n}{(1+r)^n}$$

- CF = cash flow for a period
- r = discount rate
- n = number of periods
- The value of a company can be calculated as the present value of a string of cash flows
- There is no maturity so n = ∞
- Cash flows are not simple coupons like with a bond but must be estimated
- r is not the yield of the bond, but is a discount rate that reflects the return that the investor expects under the base case. It depends on the risk perception of the investor, high risk will be high r and vica versa

If the company grows steadily at a rate g then the PV can be calculated as follows:

$$PV = \frac{CF_1}{r-g}$$

Whereas Valuing a young company with a 5 year start-up phase:

$$PV = \sum_{i=1}^{5} \frac{CF_i}{(1+r)^i} + \frac{TV}{(1+r)^5} = \sum_{i=1}^{5} \frac{CF_i}{(1+r)^i} + \frac{\frac{CF_6}{r'-g}}{(1+r)^5}$$

- r' = target rate of return of mature business
- r = target rate of return during startup phase
- We discount the estimated cash flows during the startup phase individually
- We calculate the TV(Terminal Value) of the company 5 years in the future (i.e the 6th CF), when it has reached a state of maturity growth
- We discount this TV

3.1 Bubbles

Normal Stock behavior: Share prices follow a Geometric Brownian Motion (Random walk motion) composed of a drift (expected price increase of that stock) and a noise i.e the risk part of the equation (the volatility of the stock). The Geometric Brownian Motion random walk implies that prices follow an exponential track decorated with noise. In real markets, growth rates are not stable.

Regime: A time period where stock prices dont follow brownian Motion and change faster than exponential. (Trick to detect bubbles: if you switch to a log scale and increase is still high)

Efficient Market Hypothesis

Description of Bubble:

- Bubble starts with a new opportunity or expectation
- Smart money flows in, which leads to a first price appreciation
- Attracted by the prospect of higher returns, less sophisticated investors follow
- Demand goes up as the price increases and the price goes up as the demand increases. This creates a positive feedback mechanism. The market is fully driven by behavior and sentiment and no longer reflects any real underlying value
- At some point investors start realizing that the process is no longer sustainable and the market collapses
- The crash occurs because the market has entered an unstable phase.
- The mechanism is often not well understood and a great controversy rises about the cause of the crash

exogenous process: Cause and effect are linearly and logically connected (What is important is the trigger e.g asteroid hitting earth, state of earth is irrelevant)

endogenous processes: cause and effect are not linearly connected (What is important is the state of the system, any small event can trigger a major incident)

Complex Systems:

- Consist of a large ensemble of agents e.g molecules, stars, animals, humans etc
- These interact e.g repel, attract, imitate etc.tem There is Emergence i.e local interactions lead to global cooperation in absence of any global orchestrations

Chapter 4

Wrapping up the deal

Before drafting the legal documents: There must pe an agreement on the most important principles of the deal:

- **Amount Invested** and how it will be made available (single paymen or tranches)
- **Value of the company** (with distinction of pre- and post money valuation)
- **Cap table** i.e who owns what percentage of the company
- **Governance principles**

The order is important!

Amount Invested: Based on all the information gethered during the due diligence the investor will calculate a number of cash burn scenarios. This will be used to assess the amount of capital that needs to be invested. **Capital invested in a startup is used for burning cash, so its important to have a good understanding of different cash burn scenarios.** Investors may have an incentive to start with a low initial investment, if things go well they will have a higher ROI, if things go bad, they can invest the additional amount at a lower company valuation. Hence it is important as a founder/entrepreneur to negotiate for a strong cash buffer. If the cash burn is higher than expected, you may need to find new capital in a situation under stress. At that time your company valuation will be low and you will dilute (i.e losing ownership of the company)

Value of the company: Example Below: They wanted to scale up Revenues by a factor of 10 in the next 3 years (didn't happen hence they needed a second round of investments). Steps of Analysis:

(i) Calculate Gross Margin by Revenues - COGS = 777 - 358 = 419

(ii) Subtract OPEX from the Gross Margin to get EBIT i.e 419 - 459 = -40

(iii) EBT = EBIT - interests = -40 - 9 = -49

(iv) Calculate the Cash Flows

(v) You notice that there is a big cash out, this comes from the big OPEX(hiring for sales) and CAPEX(investments) i.e big fixed costs but the return only comes a year later hence the first years will be negative, hence to valuate the company you must discount these cash flows back aswell as its Terminal Value when the company has reached a constant growth rate.

(vi) the Terminal Value can be calculated using a multiple (here the EV/EBIT multiple which was 10.0)

(vii) with the given ROE we can discount the TV and calculate the Discounted Cash Flow(DCF) = EV

(viii) Pre Money is calculated by adding the Cash and subtracting the Debt from the DCF

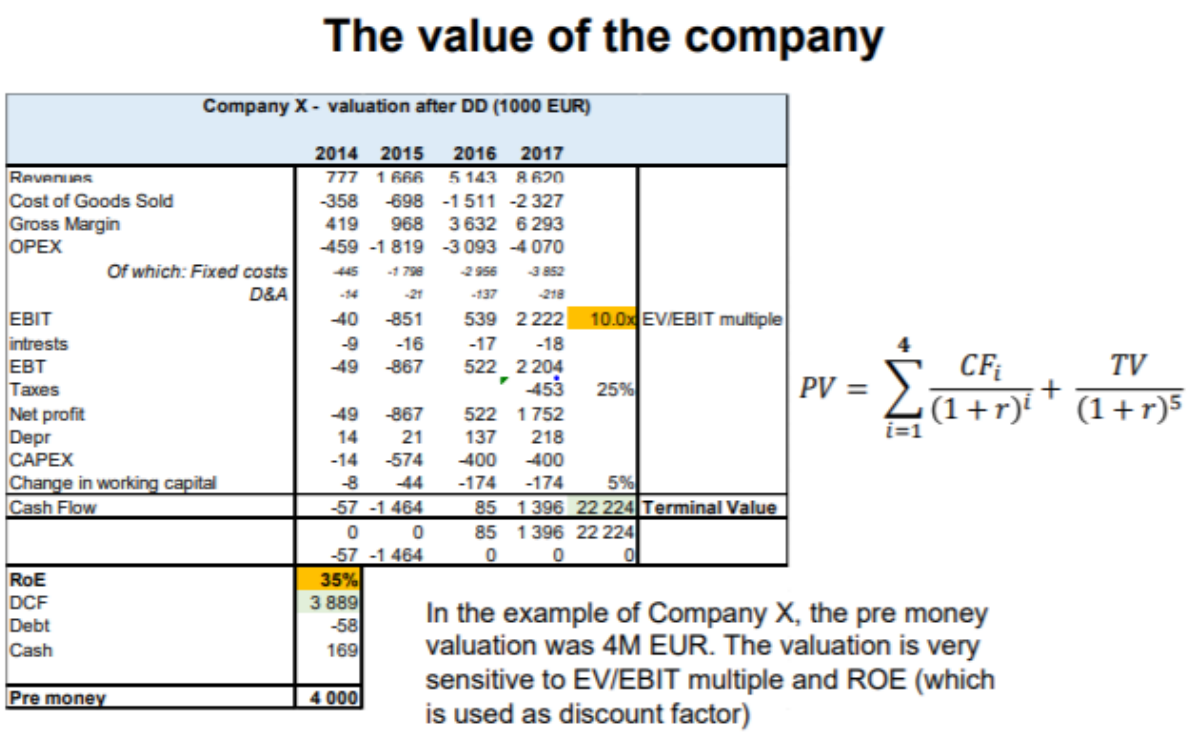


Figure 4.1: Calculation of Pre-Money valuation

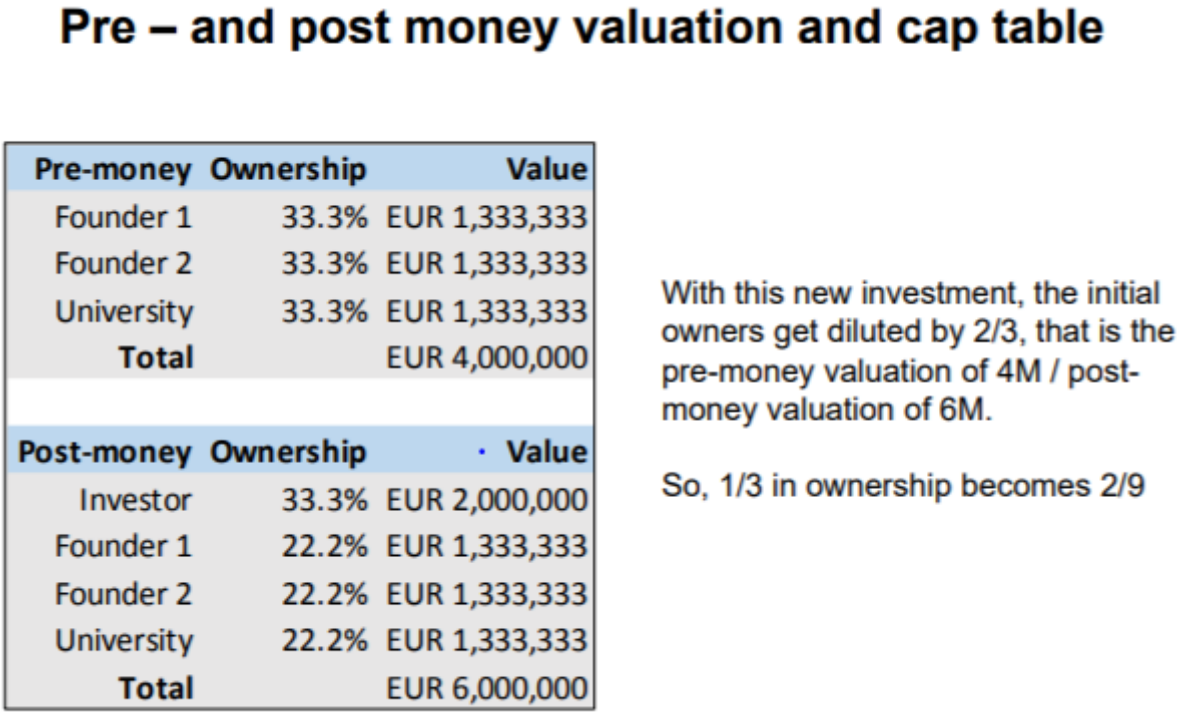


Figure 4.2: Pre/Post-Money

Pre - and post money valuation and cap table: The Pre Cap Table is the situation before the investor puts money into the company.

$$Dilution = \frac{(Pre\ Money\ Ownership) \cdot (Total\ value\ of\ company\ pre\ money)}{Total\ value\ of\ company\ post\ money}$$

Governance Principles:

- **What?**
  To outline the responsibility, composition and authority(decision making process) of the Management Team(MT), Supervisory Board(SVB) and General Meeting of Shareholders(GMS) of the company. (These are the 3 Corporate bodies of a company)
- **Why?**
  To allow for an efficient management of the company based on objective criteria and processes independently of existing persons and historical relationships
- **How?**
  By writing or changing the articles of association and/or the shareholder agreement, where needed

Corporate bodies:

Management Team: **Day-to-day affairs**

- Directs the company's day to day affairs
- Has the authority to decide in line with the annual budget and business plan that has been approved by the board
- In case of a significant deviation from the budget and the business plan, the decision is escalated to the board
- Often a matrix is drafted showing clearly the decision authority of each of multiple MT members ordered according to subject, amount, signing authority...

Supervisory Board: **Supervision**

- Composed of representatives of the shareholders + independent board members(non-executive) + senior management (executive)
- Composition and voting rights are clearly defined in the shareholders agreement
- Must supervise and advise the management and oversee the general affairs within the company
- Should be guided by the interests of the company

Typical decision authority of the board:

- Hire/fire of senior management
- Adoption and/or amendment of yearly business plan and budget
- Investments, loans, contracts ... exceeding a threshold
- Option plan for employees

- Targets and variable remuneration of senior management

General meeting of shareholders: **Value Creation**

- Composed of the shareholders (owners) of the company
- May give priority to their own interests with due regard for the principles of reasonableness and fairness
- Meets at least once per year to approve the annual accounts, discharge the board and follow up and/or adapt the Value Creation Plan (Long term business plan)
- Appoints the members of the Supervisory Board and sometimes also members of the management team (like the CEO)
- Decides by majority unless explicitly stated differently in the shareholder agreement

Typical decision authority of shareholders:

- issue new shares
- hire/fire new CEO
- distribution of dividends
- Reorganisation of the business
- Application for bankruptcy
- . . .

⇒ Any decision which will largely influence the value of shares

Legal Documents:

- Subscription Agreement (the transaction)
- Shareholders Agreement (governance and organisation)
- Management Agreement (day-to-day operations)

Subscription Agreement **The Transaction**

- A Subscription Agreement is between a company and a private investor to sell a specific number of shares ata specific price.
- it contains amongst others, information regarding the amount invested, the cap table, issue of new shares or transfer of existing shares, payment conditions, conclusions on the due diligence, warranties, . . .
- Some agreements include a specified rate of return that investors are guaranteed to receive ("preference Shares")

Shareholders Agreement **Governance and Organisation**

- A shareholders agreement describes how the company should be operated and outlines shareholders rights and obligations.
- Is intended to make sure that all shareholders are treated fairly and that their rights are protected
- Outlines the governance principles: the responsibility, the composition and the authority of the MT, SVB and the GMS of the company
- Describes the exit scenarios (transfer of shares) with specific care for the rights of minority as well as majority shareholders

Lock-up: A predetermined amount of time where shareholders are restricted from selling their shares

Right of first refusal: After the lock up period, when one shareholder can sell shares to a third party, the other shareholders must be given the opportunity to match the price and buy shares instead of the third party

Drag along: (Protection of majority shareholder) A drag along right allows a majority shareholder of a company to force the remaining minority shareholders to accept an offer from a third party to purchase the whole company at the same price,terms and conditions. Drag-along rights help eliminate minority owners and sell 100% of a company's securities to a potential buyer.

Tag along: (protection of minority shareholder) Tag along rights are the inverse of drag along rights. When a majority shareholder sells their shares, a tag along right will entitle the minority shareholder to participate in the sale at the same time for the same price, terms and conditions. The minority shareholder then tags along with the majority shareholder's sale.

Good/Bad leaver clause: A description of the circumstances in which a person ceases to be an employee of a company (For founders, often this leads to forced selling of the shares)

Good leave: Usually due to illness,disability to work, death or (early) retirement. (Founders get market value for their shares)

Bad leave: Voluntary leave before end of contract, compelling cause e,g criminal activity (Founders get way less than market value for their shares)

Negotiations: Finalisation of the legal documents may take quite some time. There will be negotiations and small print will be read and discussed in great detail.

Final Step: Signing at the notary office

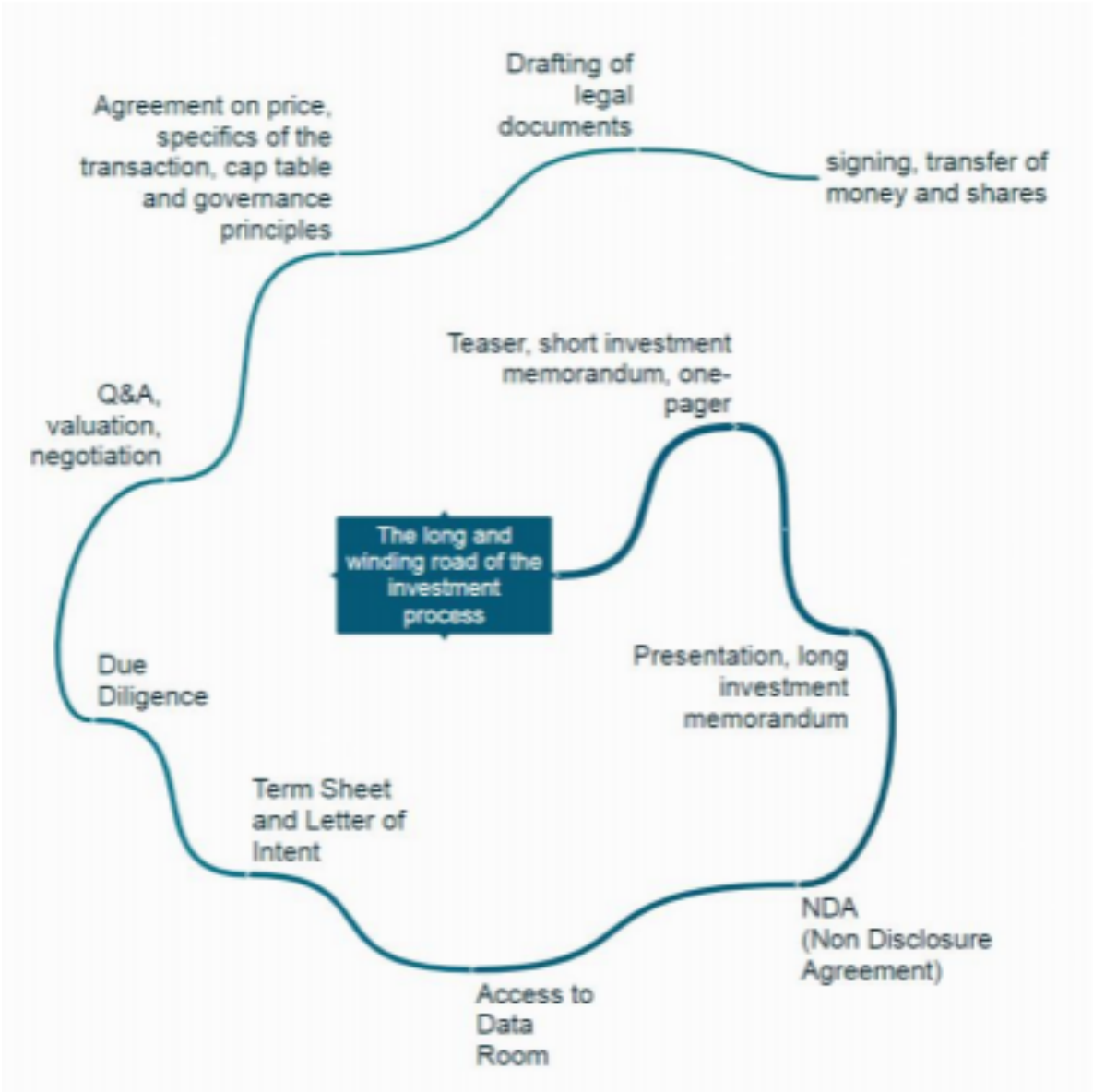

Drafting of legal documents
Agreement on price, specifics of the transaction, cap table and governance principles
signing, transfer of money and shares
Teaser, short investment memorandum, one-pager
Q&A, valuation, negotiation
The long and winding road of the investment process
Due Diligence
Presentation, long investment memorandum
Term Sheet and Letter of Intent
NDA (Non Disclosure Agreement)
Access to Data Room

Figure 4.3

Chapter 5

On The Quantative Definition of Risk:
(Paper by Stanley Kaplan, John Garrick)

5.1 Qualitative aspects of the notion of risk:

Distinction Between Risk and Uncertainty: The notion of risk involves both uncertainty and some kind of loss or damage that might be received, hence

$$risk = uncertainty + damage$$

Distinction Between Risk and Hazard: Hazard exists as a source, risk includes the likelihood of conversion of that source into actual delivery of loss, injury or some form of damage. Safeguard is something to protect us against the hazard and minimize the risk. It also includes the idea of awareness of risk.

$$\frac{hazard}{safeguards}$$

Note: The Risk can become small, but it is never zero

Relativity of Risk: Risk is relative to the observer and is a subjecive thing (e.g Rattlesnake in Mailbox)

5.2 Quantative definition of risk:

Set of Triplets idea: A risk analysis consists of an answer to the following questions:

(i) What can happen? (What can go wrong)

(ii) How likely is it that that will happen?

(iii) If it does happen, what are the consequences?

If we can give each possible scenario a probability and the respective damage, we have found the risk.

$$R = \{\langle s_i, p_i, x_i \rangle\}, \quad i = 1, 2, \ldots, N$$

Table I. Scenario List

Scenario	Likelihood	Consequence
S_1	p_1	x_1
S_2	p_2	x_2
$\cdot$	$\cdot$	$\cdot$
$\cdot$	$\cdot$	$\cdot$
$\cdot$	$\cdot$	$\cdot$
S_N	p_N	x_N

Figure 5.1

Risk Curves: We now sort the scenarios by increasing severity of damage and add a column containing the cumulative probability. Plotting this results in a stair case function, which can be seen as a discrete approximation to a continuous reality. Hence we can construct a smoothed curve R(x) representing the actual risk i.e the "risk curve".

Multidimensional Damage In many applications, it is appropriate to identify different types of damage, hence the damage x can be regarded as a vector quantity rather than a scalar. The risk curve becomes a risk surface.

5.3 Probability

The Definition of Probability and Distinction Between Probability and Frequency

- **probability:** A numerical measure of a state of knowledge, a degree of belief, state of confidence
- **frequency:** The outcome of an experiment involving repeated trials.

$\Rightarrow$ In concept, frequency is a well defined, objective, measurable number. Probability on the otherhand is changeable and subjective.

Distinction between Probability and Statistics: Statistics is the study of frequency type information i.e the science of handling data, wheras Probability is the science of handling the lack of data.

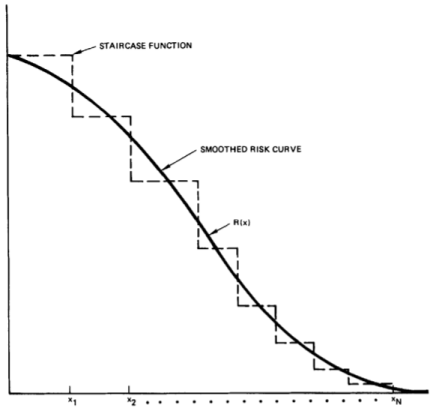


Figure 5.2: Risk curve

5.4 Level 2 Definition of Risk

Risk Curves in Frequency Format: We adjust the triplets and execute a thought experiment, keeping track of how many times each scenario occured. We then compute the cumulative frequency $\phi_i = \sum_{x_j \geq x_i} \phi_i$ and plot it against x (sum is over all scenarios having damage equal to or greater than x_i

Inclusion of Uncertainty: When creating the risk curve we have not yet actually done the experiment hence we have uncertainty of what its outcome would be, which is proportional to the total state of knowledge as of right now. Since the thing we are uncertain about is a curve $\phi(x)$, we express the uncertainty by embedding this curve in a space of curves and creating a probability distribution over this space.

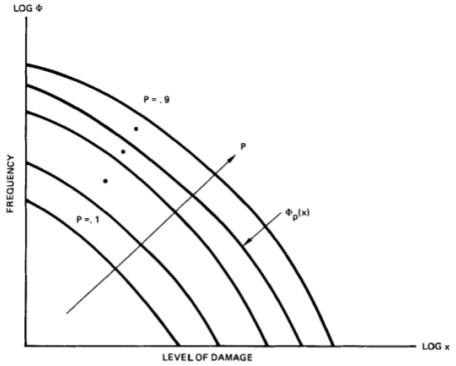


Figure 5.3: Risk curve in probability of frequency format

Set of Triplets Including Uncertainty When the frequency with which scenario category s_i occurs we can express our state of knowledge about this frequency with a probability curve $p_i(\phi_i)$, which is the probability density function for the frequency ϕ_i, of the ith scenerio.

$$R = \{\langle s_i, p_i(\phi_i), x_i \rangle\}$$

This set of triplets is the risk including uncertainty in frequency

5.5 "Acceptable Risk"

Difficulties with the notion of acceptable risk:

(i) The minor difficulty is that it implies that risk is linearly comparable i.e it implies that one can say that risk of course of action A is greater or less than that of design B, which they are not. It would be possible to reduce the risk curves to a single number, but alot of information would be lost.

(ii) The major difficulty is that risk cannot be spoken of as acceptable or not in isolation, but only in combination with the costs and benefits that are attendant ot that risk. One must adobt a decision theory point of view and ask: "What are my options, what are the costs, benefits and risks of each?"

Chapter 6

The Logistic equation of growth, saturation and diffusion and generalized logistic growth modeling of the covid-19 outbreak

The logistic equation: Growth and saturation in an environment with competition for limited resources e.g How does a rabbit population grow when resources are unlimited versus limited? The size of a population, with competition for limited resources grows according to a very specific process. It has an **S-shape**. The growth of a population P in competition can be described by

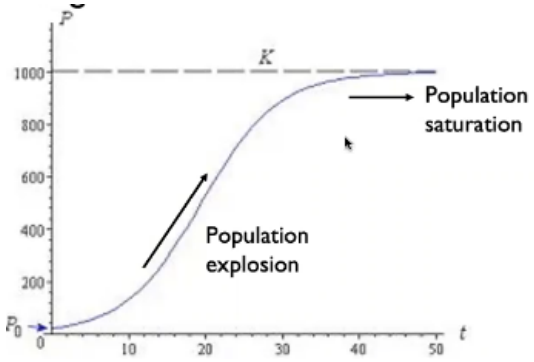


Figure 6.1: P_0 := initial population

the logistic differential equation:

$$\frac{dP}{dt} = rP(t)\left[1 - \frac{P(t)}{K}\right]$$

- $\frac{dP}{dt}$ derivative of the population with respect to time
- r is a growth rate
- K is the capacity
- $\left[1 - \frac{P(t)}{K}\right]$ is the saturation term. When P(t) gets closer to K the saturation term approaches zero hence $\frac{dP}{dt}$ approaches 0, indicating no growth.

The solution to this differential equation with P_0 being the initial population is called the **logistic function**:

$$P(t) = \frac{KP_0e^{rt}}{K+P_0(e^{rt-1}}$$

If there are no limitations, K is infinite and: $P(t) = P_0e^{rt}$

Example: rabbit population

Suppose an initial population of 2 rabbits, doubling the first year, with a carrying capacity of 1'000. What does limited and unlimited growth looks like?

The first year growth is exponential. From this we can determine r:

$P(t) = P_0 e^{rt} = 2e^{rt} \quad \Rightarrow \quad P(t=1) = 2e^{r} = 4 \quad \Rightarrow \quad r = \ln(2) \approx 0.693$

Result: $P(t) = \dfrac{KP_0 e^{rt}}{K + P_0\left(e^{rt} - 1\right)} = \dfrac{2000 e^{\ln(2)t}}{1000 + 2\left(e^{\ln(2)t} - 1\right)}$

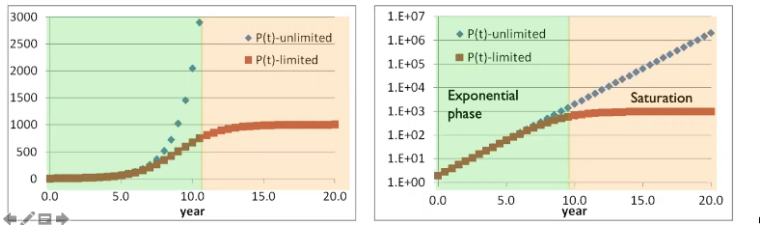


Figure 6.2: left: linear scale , right: log scale

Phenomenological Models: An empirical approach without a specific basis on the physical laws or mechanisms that give rise to the observed patterns in the data. Much simpler and more intuitive models.

- emphasize the reporducibility of empirical observations using simple models

Mechanistic models: Incorporate key physical laws or mechanisms involved in the dynamics of the problem under study (e.g population or transmission dynamics) in order to explain patterns in the observed data

- often formulated in terms of a dynamical system describing the spatialtemporal evolution of a set of variables and are useful to evaluate the emergent behavior of the system across the relevant space of parameters.

Model Error: The idea that there is no model that is right, hence we use different models and realize what they represent (lower bound, upper bounds,opposmistic ...), we then can compare their fitting capabilities and forecast we can develop a view of how sensitive the forecast and our interpretation is on the specific model we use. If the models converge than we can conclude that we understand the situation, whereas if they diverge we must be more cautious.

Logistic Growth: Generalisations: Many systems exhibit succession of S-curves because advances in technology etc. increase the carrying capacity K. The idea is to include this into the logistic equation with a population dpendent carrying capacity with delay time τ hence:

$$\frac{dP}{dt} = rP(t)\left[1 - \frac{P(t)}{K(t)}\right] \text{ with } K(t) = A + BP(t-\tau)$$

Where A is a constant like before and the term $BP(t-\tau)$ now includes some technological improvement with delay (because people arent productive until later years of their life). B is the rate of change in population (increases if positive, decreases if negative). A negative B corresponds to a destruction of habitats.

$$\Rightarrow \frac{dx}{dt} = x(t) - \frac{x^2(t)}{a + bx(t-\tau)}$$

With $x \sim P$ and parameters a,b related to r,A and B.

Generalised logistic growth equation:

$$\frac{dx}{dt} = x(t) - \frac{x^2(t)}{a + bx(t-\tau)}$$

individual growth/gain term — competition term

Four possible scenarios:

$$\frac{dx}{dt} = x(t) - \frac{x^2(t)}{a + bx(t-\tau)} \quad \text{(gain \& competition)}$$

$$\frac{dx}{dt} = x(t) + \frac{x^2(t)}{a + bx(t-\tau)} \quad \text{(gain \& cooperation)}$$

$$\frac{dx}{dt} = -x(t) - \frac{x^2(t)}{a + bx(t-\tau)} \quad \text{(loss \& competition)}$$

$$\frac{dx}{dt} = -x(t) + \frac{x^2(t)}{a + bx(t-\tau)} \quad \text{(loss \& cooperation)}$$

coupled logistic equations: Instead of only one species (industry etc.) we can also have two interacting species:

$$\frac{dx}{dt} = x - \frac{x^2}{1+bxz} \qquad \frac{dz}{dt} = z - \frac{z^2}{1+gxz}$$

x = species one and z = species two. The carrying capacity now depends not only on the one species but on the product of both.

Logistic map: A discretised version of the logistic equation:

$$x(n+1) = \alpha x(n)[1 - x(n)]$$

with α = r + 1

definition of chaos: Chaos is not random, but due to a deterministic map:

$$x : A \to B$$

satisfying the following properties

- x is low dimensional i.e x is only dependent on a small number of variables
- x is deterministic i.e the next value can always be predicted exactly
- x is sensitive to initial values
- trajectories of x are reinjected i.e although slight differences in initial values x_1 and x_2 lead to trajectories which can be arbitrarily far apart from each other, there will be a point at which these two trajectories are again arbitarily close to each other.

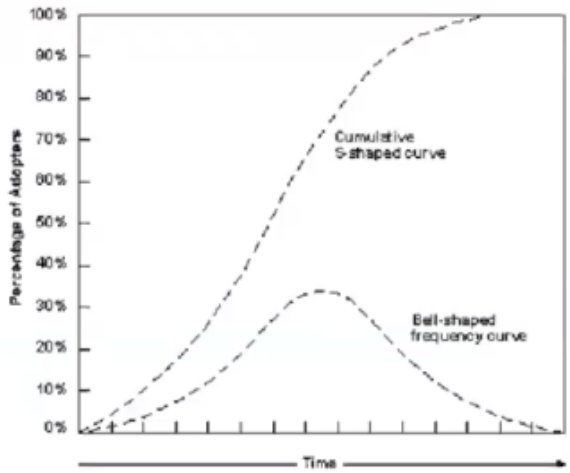
Chaos is the sensitivity to initial conditions.

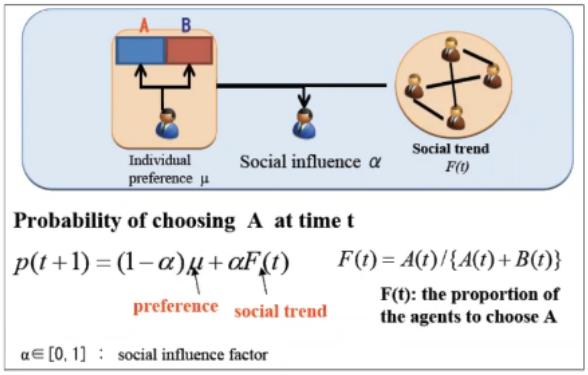
Random vs Chaotic: How can we distinguish a random map from a chaotic one? Both maps generate extremely complicated behaviour but if we plot it over x(n+1) vs x(n) the chaotic map will resolve to a inverted parabola wheras the random map will fill the space.

Penetration rate: denoted F(t), it is the fraction of the population that has adopted the new technology. It follows an S-curve and saturates at 100% when the full population has adopted the new technology.

Penetration speed: denoted F(t+1) - F(t) it is the fraction of the population that adopts the new technology in the following time-step, this will follow a Gaussian-shaped curve. Is comparable to the production rate, it follows a Gaussian shaped curve

The Agent Based Model (ABM): p(t+1) is the probability that an agent will adopt the new technology in the next time-step. As a consequence:





$$F(t+1) - F(t) = p(t+1) \cdot (1 - F(t))$$

the penetration rate is the probability that an agent adapts multiplied with the number of non-adapted agents

$$\Rightarrow F(t+1) = F(t) + p(t+1) \cdot (1 - F(t)) = F(t) + ((1-\alpha) \cdot \mu + \alpha \cdot F(t)) \cdot (1 - F(t))$$

In case there is no personal preference and **only social interaction**:

- μ=0;
- F(t+1) = F(t) + α∗F(t) ∗(1-F(t)).

Continuous:

- dF(t)/dt = α∗F(t) ∗(1-F(t))
- This is the logistic differential equation with K=1;
- 100% penetration rate agrees with a carrying capacity of 1;
- and r=α.

Indeed, the logistic equation (and in its limit the exponential function) describes the population size of rabbits and change in population sizes of rabbits requires social interactions.

In the case there is **only personal preference**, and no social interaction or context:

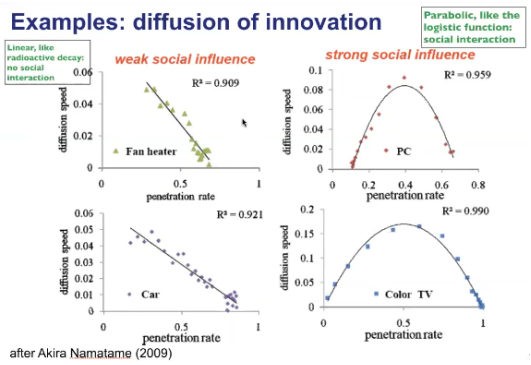
- α=0;
- F(t+1) = F(t) + μ ∗(1-F(t))

Continuous:

- dF(t)/dt = μ ∗(1-F(t))
- F(t) = 1 − exp(-μ ∗t);

This is like radioactive decay, the concentration of the parent nuclei drops exponentially and the concentration of the daughter nuclei (the penetration rate) increases with 1 − exp. Indeed there is no social interaction between the nuclei.

When there is more social interaction, the function becomes more stepwise. When there is lower social interaction the relation becomes linear



Case Study-The valuation of Facebook before the IPO: Even Facebook follows the law of diffusion of new technology or newly launched products, hence the cumulative users of Facebook follow a Logistic Function or S-curve. S-curves possess predictability and allow us to forecast the future user growth of the company. Social networking companies derive most of their revenues through advertisement i.e there is a clear relationship between users and revenues:
⇒ Based on the Forecasted users, we can predict future revenues
We get the following equation (Gordon Sharpiro):

$$valuation = \sum_{t=1}^{end} \frac{r(t) \cdot MAU(t) \cdot p}{(1+d)^t} = \sum_{t=1}^{end} \frac{profits}{(1+d)^t}$$

- We model the Monthly Active Users: MAU(t)
- We model the revenues per user: r(t)
- Define profit margin: p
- Profits at time t:$r(t) \cdot MAU(t) \cdot p$
- Define the value of the company as the sum of all the discounted future profits using a discount rate d

GreenShoe Option: A greenshoe option is also called an over-allotment option. At the IPO, the underwriters sold 15% more shares then what was initially targeted, creating a big short position. If the price goes up, covering this short would be extremely expensive. When the underwriters execute the greenshoe option, Facebook must emit 15% more shares at the IPO price. This allows them to cover their position without any loss. If the price goes below the IPO price, they can close the short position, buy back the shares at the IPO price and as such support the price at the IPO level. The purpose of the greenshoe option is to artificially prop up the price in case of an IPO that is not well received by the market.

Three important laws of valuation and investment:

1. Prediction is not extrapolation, understand the underlying process e.g the logistic function is exponential in the beginning but plateaus after the inflection point
2. Understand the technicalities of the market and of the investment banking. E.g The flat price at 38 was a clear signal that the price was artificially supported by the greenshoe option.
3. Always RTFM - (Read the Fucking Manual!) e.g when does the lock-up period end (the moment insiders can start selling)

Chapter 7

150 years perspective on society economy and technology

Five distinct time periods:

- Gilded age 1870 - 1910
- First shift 1911 -1946 (wars, revolutions,...)
- Golden Age 1947-1968
- Second shift 1969-1979 (oil crisis)
- Fools Gold Age 1980 - ongoing

Shift: When one structural economic regime passes into another. Because each shift experiences the end of one era and the beginning of another, it always comes with geopolitical, financial and economic disruption.

The Gilded Age:

- Era of rapid expansion of heavy industries and infrastructure
- Accelerated innovation from the Technological Revolution led to interconnected growth: Telegraphs,railroads,steamships,...
- First wave of globalization: Rise of the "haute finance" centered around the gold standard with the british pound as reserve currency
- The stock market, during those decades was solid, with high earnings qualities and a strong underlying economic growth
- The balance of power between the newly created nation states, guaranteed geopolitical stability. This prevented the occurrence of any long and devastating war between the Great Powers. In France this epoch was called the Belle Epoque

Inequality at a historical high:

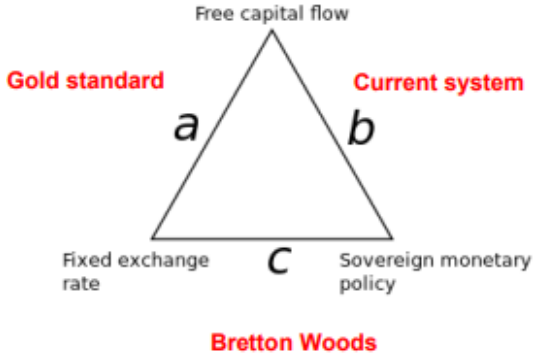
- Urbanization and migration led to an oversupply of labor in cities
- a stagnation of real wages
- decline of the proportion of GDP going to labor

Robber baron capitalism and winner-takes-all markets created monopolies, hence the fruits of progress stayed in the hands of the happy few (Railway, Steel, Banks,...) A period of wild financial and economic expansion with a lack of institutions and regulations to smoothen boom and fight bust. As a result we see multiple cycles of $boom \rightarrow panic \rightarrow depression$

- 8 years of overinvestment and speculation, and a railroad boom after the end of the American Civil War (1865) ended in the panic of 1873
- This was followed by the long depression which lasted until 1879
- A new boom started pushed by the Technological Revolution, this lasted until the panic of 1893
- Ensued by another depression which lasted until 1897
- Followed by another boom, which ended in a massive banking crisis in 1907

The Gold standard (The Gilded Age): Money is linked to gold, so the standard unit of account in the economy is gold. Because of this, ite becomes difficult for countries to create money i.e expand the money supply to stimulate the economy. This was adopted internationally so capital could flow freely from one country to another, and you could always exchange your currency for gold, so this was a serious protection for owners of capital. Nations that adopted the gold standard were forced to manage capital flows instead of employment.

- When there was a recession, governments increased interest rates to stop the outflow of capital (and gold)
- Because the crisis could not be countered with expansionary monetary policies, the economy contracted, hence there was less demand in labor and in goods, would make prices drop.
- the supply of cheaper products would make a country more competitive on the global markets. This would rest



The trilemma of international finance: Economic policy makers wnat to achieve three goals:

- Open their country's economy to international flows of capital to bring in foreign capital and to allow the nations citizens to diversify their investments abroad
- Follow an independent monetary policy to stabilize their economy and support employment in times of need (if times go bad they want to pump liquidity into the economic system)
- Have a fixed foreign exchange rate which brings stability and trust in international trade and investment

You can only have two of three at any given time:

- **Gilded Age:** Fix exchange rate and let money flow freely across the globe at the loss of an independent monetary policy
- **Golden Age:** Fix exchange rate and follow independent monetary policy at the loss of free capital flows
- **Fools Gold Age:** Follow independent monetary policy and let money flow freely across the globe at the expense of a fixed exchange rate.