

Entrepreneurial Risk

Summary

Balázs Szekér

szekerb@student.ethz.ch

Summary of the Lecture Entrepreneurial Risk
in the Spring Semester 2021 given by Didier Sornette

Swiss Federal Institute of Technology, ETH Zürich

June 8, 2021

Preface

This is a summary of the topics dealt with in the lecture Entrepreneurial Risk in the spring semester 2021 given by Didier Sornette at ETH Zürich. This script is based on the lecture slides provided by Prof. Didier Sornette. All images and illustrations in this Script were taken from the lecture slides. The list of topics is not exhaustive. Many things were left out and only the topics which the author regarded as important are mentioned. This summary should neither be considered as a replacement of the lecture nor as a sufficient preparation for the exam. This summary should only be a reminder to which you can resort in case you quickly want to look something up. No liability is accepted in the event of failure to pass the examination.

If you stumble over mistakes, be it linguistic or thematic, or if you have suggestions what to add or how to improve this script, do not hesitate to contact me at szekerb@student.ethz.ch.

Many Thanks

Balázs Szekér

Contents

| | | |
|----------|---|-----------|
| 1 | Introduction | 1 |
| 1.1 | Entrepreneurship | 1 |
| 1.2 | Risks | 1 |
| 2 | Setting the landscape on entrepreneurship and private investment | 3 |
| 3 | Introduction to company valuation | 10 |
| 3.1 | Balance Sheet | 10 |
| 3.2 | P & L - Profit and Loss | 10 |
| 3.3 | Cash-Flow Statement | 11 |
| 3.4 | Company Valuation | 12 |
| 3.5 | Limits of markets,complex systems and financial bubbles | 14 |
| 4 | Wrapping up the deal | 16 |
| 4.1 | The amount invested | 16 |
| 4.2 | Value of the Company | 16 |
| 4.3 | Cap Table | 17 |
| 4.3.1 | Governance principles | 17 |
| 4.3.2 | Corporate Bodies | 17 |
| 4.3.3 | Legal Documents | 18 |
| 4.3.4 | Negotiation | 20 |
| 4.3.5 | Signing at the notary office | 20 |
| 5 | The logistic equation of growth, saturation and diffusion | 21 |
| 5.1 | The logistic equation | 21 |
| 5.1.1 | Mathematical formulation | 21 |
| 5.1.2 | Mathematical solution | 21 |
| 5.1.3 | Different representations of logistic growth | 21 |
| 5.1.4 | The Hubbert model and peak oil | 21 |
| 5.1.5 | Two types of models to describe epidemics | 21 |
| 5.1.6 | Population growth - Exponential | 22 |
| 5.1.7 | Generalized growth model | 22 |
| 5.1.8 | Extension of Logistic type model | 22 |
| 5.2 | Generalized logistic growth modeling of the Covid-19 outbreak | 23 |
| 5.3 | Generalization of logistic equations | 24 |
| 5.3.1 | Generalized logistic growth equation | 24 |
| 5.3.2 | Nonlinear carrying capacity | 24 |
| 5.3.3 | Coupled logistic equations | 25 |
| 5.4 | Introduction to Chaos Theory | 25 |
| 5.4.1 | The logistic map | 25 |
| 5.4.2 | Number Theory: roots of randomness | 26 |
| 5.4.3 | Chaos | 26 |
| 5.5 | The diffusion of innovation | 27 |
| 5.5.1 | The Agent Based Model (ABM) of Namatame | 27 |
| 5.6 | Case Study - the valuation of the company Facebook before the IPO | 28 |
| 5.6.1 | Ex-ante prediction | 29 |
| 5.6.2 | Conclusion | 29 |
| 6 | A 150 years perspective on society, economy and technology | 30 |
| 6.1 | The Gilded Age (1870 - 1910) | 30 |
| 6.1.1 | The trilemma of international finance | 32 |
| 6.1.2 | Shifts | 32 |
| 6.2 | The First Shift (1911 - 1946) | 32 |
| 6.2.1 | Bretton Woods | 33 |
| 6.3 | The Golden Age (1947 - 1968) | 34 |
| 6.4 | The Second Shift (1969 - 1979) | 34 |
| 6.5 | The Fool's Gold Age (1980 - ...) | 35 |

| | | |
|-----------|---|-----------|
| 6.5.1 | Three waves of globalization | 36 |
| 6.5.2 | ETF impact example: Negative oil prices | 37 |
| 6.5.3 | Bubble of everything 2007 | 39 |
| 6.5.4 | Central bank policies as slaves to the stock market | 39 |
| 6.6 | Conclusion | 40 |
| 6.6.1 | A new bipolar world with two great "empires"? | 42 |
| 7 | The macro status in China and the potential opportunity and risk for the World | 46 |
| 7.1 | China has woken up and become an integral part of the world | 47 |
| 7.2 | China is an old superpower with a recent brief dent (How China fell and woke up) | 50 |
| 7.2.1 | Century of Humiliation (1839-1949) | 51 |
| 7.3 | China is a Confucian dominant country (East and West culture difference) | 53 |
| 7.3.1 | Confucianism | 53 |
| 7.4 | China is internally highly heterogeneous and complex | 55 |
| 8 | The collision of the two opposite mindsets: Innovation and Entrepreneurship in China and Switzerland | 57 |
| 8.1 | Switzerland is an old friend of China | 57 |
| 8.2 | Competence of the two nations | 59 |
| 8.3 | Swiss startups and innovation | 61 |
| 8.4 | Chinese startups and innovation | 62 |
| 8.5 | Opportunities | 64 |
| 9 | Knowledge and economic growth. A history of discovery, invention and innovation. | 65 |
| 9.1 | On the nature of economic growth | 65 |
| 9.2 | On the productivity of research | 67 |
| 9.3 | On the nature of knowledge | 67 |
| 9.3.1 | What is "knowledge"? | 67 |
| 9.4 | How do we innovate, invent or discover? | 68 |
| 9.5 | The industrial revolutions, four waves of industrial innovation | 70 |
| 9.6 | A critical assessment of the industry 1.0 : 4.0 framework - The Chinese case | 72 |
| 9.7 | A critical assessment of the industry 1.0 : 4.0 framework | 73 |
| 9.8 | Conclusion | 73 |
| 9.9 | In our research group, we are trying to contribute to solving this puzzle. Here are some very recent results | 74 |
| 9.10 | How to quantitatively formulate the problem of exploitation of an existing set of invention, innovation and exploration | 74 |
| 10 | Humanity in the Anthropocene | 77 |
| 10.1 | The Secret History of Silicon Valley | 77 |
| 10.1.1 | Story 1: WWII The First Electronic War | 77 |
| 10.1.2 | Story 2: The Electronic Shield-Electric Warfare | 77 |
| 10.1.3 | Story 3: Stanford and the Cold War | 78 |
| 10.1.4 | The Rise of Venture Capital - The Limited Partnership | 81 |
| 10.1.5 | Summary | 82 |
| 10.2 | What is the State's role in the economy? | 82 |
| 10.3 | The Social Bubble Hypothesis | 83 |
| 10.4 | Certain to Win | 84 |

1 Introduction

1.1 Entrepreneurship

Definition (Entrepreneurship). • Pursuit of opportunity without regard to resources controlled.

- Process of creating value through unique resource combinations that exploit opportunity.
- A way of thinking and acting, lot of different professional contexts, but also a way of approaching personal issues, family, life, community involvement, etc...

Definition (Success). 1. Know what you want in life. Know your end goals.

2. Write down your intermediate goals and plan to reach these goals.
3. Review and revise your plan monthly, keeping track of all setbacks and progress.

1.2 Risks

"Life is risk. Risk is life."

Definition (Risk). • A risk is a potential event with negative consequences that has not happened yet. However, a risk could also be defined as the event with unforeseen positive consequences.

- A possibility of Loss - Not the loss itself!
 - A source of problem during a project
 - Avoid labelling the cost of a risk as a risk. Find the source!
 - Strike at the root of the problem, not the leaves!
- Something that makes the project special.
 - In the widest sense, everything is a risk.

Types of Risk

- Industrial Risks
 - Change in technology, productivity, prices
 - false estimation of the rated capacity
 - time needed for the construction and running-in periods, political, social and business environment
- Operational Risk
 - 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.
- Market Risks
 - Unforeseeable inflation and exchange rates change.
 - Customer behaviour to buy foreign goods.
 - Inadequate infrastructure.
 - Shrinking market because of foreign competitors.
 - Defaulting or insolvency, Credit risk.
- Cultural risks
- Natural risks

- Economic and political risks

Definition (Hazard). A hazard is an act or phenomenon posing potential harm to some person(s) or thing(s), 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.

Definition (Unknown Unknown). A type of uncertainty in which you do not know that this uncertainty even exists.

Definition (Risk assessment). Risk assessment consists of: Hazard identification, Event probability assessment and Consequence assessment.

Definition (Risk Control). Risk control require the definition of acceptable and comparative evaluation through monitoring and decision analysis. Risk control also includes failure prevention and consequence mitigation.

Definition (Risk Communication). Risk communication involves perceptions of risk and depends on the audience targeted. Hence, it is classified into Risk communication to the media, to the public and to the engineering community.

Definition (Human Errors). Human errors are unwanted circumstances caused by humans that result in deviations from expected norms that place systems at risk. It is important to identify the relevant errors to make accurate risk assessment. 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. The human error rate estimates are often based on simulation tests, models, and expert estimation.
- Human Error Quantification: Still a developing science requiring understanding of human performance, cognitive processing, and human perceptions.

2 Setting the landscape on entrepreneurship and private investment

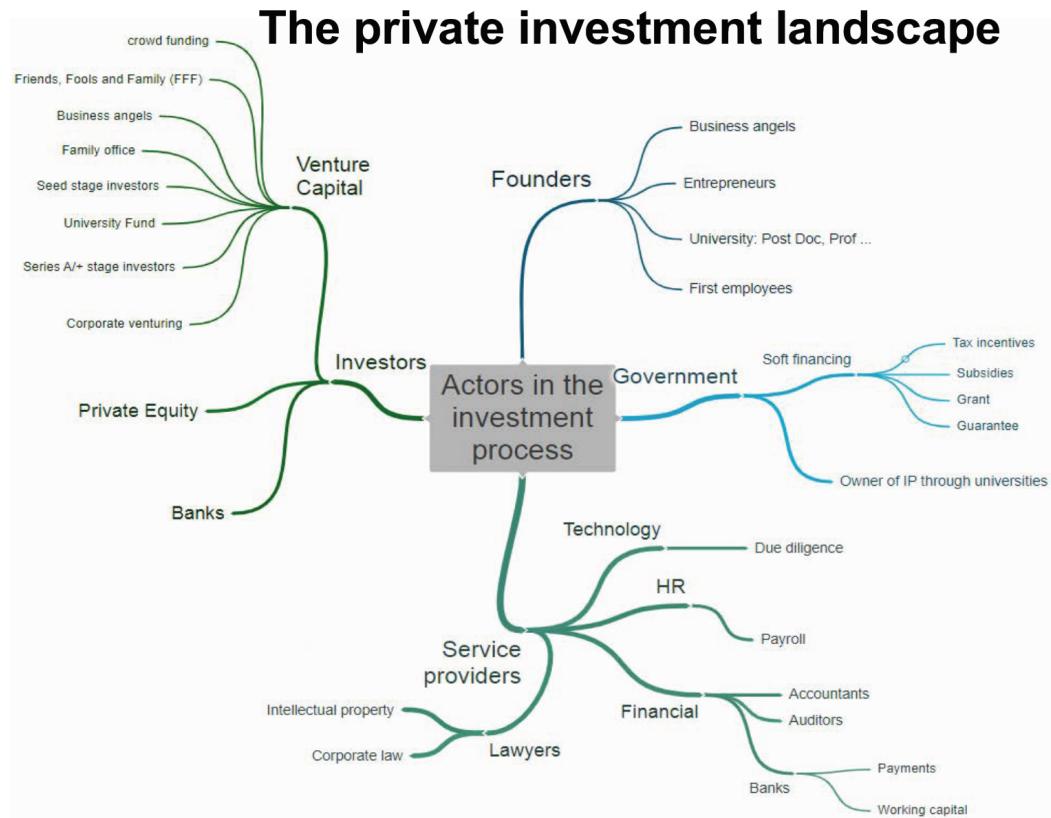


Figure 1: Private investment landscape

Difference between Private Equity and Venture Capital

Definition (Private equity).

- 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 potential returns.
- Large deal sizes (hundreds of millions)

Definition (Venture capital).

- 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)

Definition (Asset and leverage).

$$\text{Asset} = \text{Debt} + \text{Equity} \quad , \quad \text{Leverage} = \frac{\text{Asset}}{\text{Equity}} = \frac{\text{Debt}}{\text{Equity}} + 1$$

Most new businesses do not survive the first five years. 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...

Liquidation preferences

- Much VCs invest using so-called 'preference shares' instead of common shares.
- In the event of the failure of the company, preferred shareholders may receive payment from liquidation before common shareholders.
- When the company is sold (at the so-called exit), preferred shareholders may receive payment (sometimes with a guaranteed ROI) in full before the common shareholders.

The pay-off is highly skewed, many losers and a few big winners. Investors must be detached from individual companies and look at the whole portfolio. This is not aligned with the Entrepreneurs' viewpoint.

Risk and return are like Yin and Yang



Perceived vs. actual risk Two kinds of bias were identified: (a) a tendency to overestimate small frequencies and underestimate larger ones; and (b) a tendency to exaggerate the frequency of some specific causes and to underestimate the frequency of other, at any given level of objective frequency.

Prospect Theory: Kahnman and Tversky "Losses loom larger than gains." Individuals assess losses and gains in an asymmetric way e.g. for some people, the pain from losing 1000 USD could only be compensated by the pleasure of earning 2000 USD.

Viewpoints of Investors and Entrepreneurs

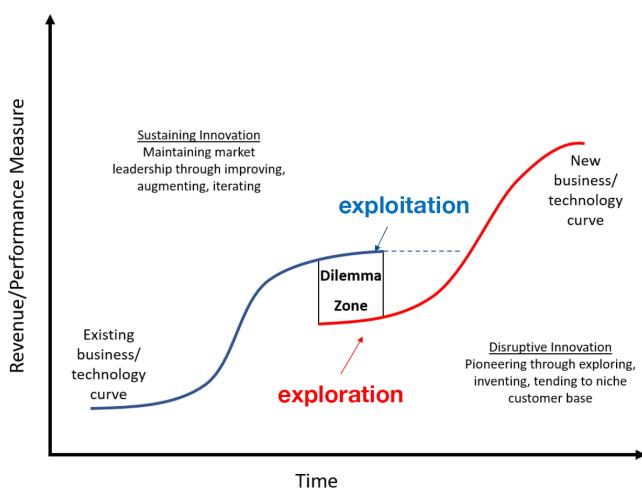
| | Entrepreneur/Founder | Investor |
|-------------------------|---|---|
| Motivation | Intrinsic | Extrinsic |
| Goal | Realize a dream | Make money |
| Horizon | Not relevant | Medium term (3 to 7 years) |
| Risk | All in | Portfolio view, highly skewed payoff with few very successful winners but 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 |

Challenges of exploration According to Herbert Simon exploration requires:

- tolerance of ambiguity/uncharted territory
- patience: learning-by-doing, accumulation of knowledge, trial-and-error
- luck / serendipity
- persistence / diligence
- 'intuition': use of smart heuristics

It is a high risk endeavor, where the payoff is almost impossible to estimate.

Exploitation Exploitation is tempting from a short-term risk/return perspective, but there are serious caveats on the long run.



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 first mover advantage against large, less nimble, market leaders.

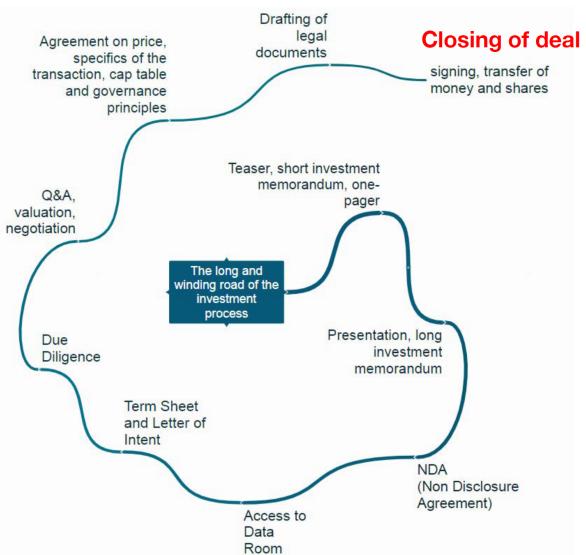
Important Terms

- Regression to the mean
- Narrow Framing

How to deal with biases?

- Heuristics: When predictability is poor, inconsistency, based on unnoticed stimuli, is destructive of any predictive validity. Be consistent by using investment criteria, simple formulas, recipes or rules of thumb.
- Example, consider an outside view: Prior to the use of any inside information, try to predict a totally independent base rate e.g. "how many start-ups in this field survive the first three years?" Use this as your anchor and adjust this base rate according to information obtained during the due diligence.
- Decorrelate error: Ask people's opinion independently of each other, wisdom of crowds vs. group think, practice "constructive confrontation", avoid "cozy unanimity"
- Sunk Cost: Be aware of the difficulty to take a loss. A new manager does not carry the same mental accounts and is therefore more able to ignore the sunk cost of past investments.
- Validity of intuition: Intuition cannot be trusted in the absence of stable regularities in the environment and in the absence of prolonged practice and learning.

Closing a deal Only a fraction (0.5-2%) of considered deals get closed.



Pitch Deck

- Sales pipeline, proven market interest, test by the market...
- Growth strategy: sales, product development, scalability, BOM
- Investment: Use of proceeds
- Current cap table
- Exit options for investor



Figure 2: Pitch Deck

Get to know each other Possible Questions:

- Team:
 - Does your company culture and values math with us?
 - Are there complementary skills in your core team?
 - Can you give references for your key employees?
- Technology:
 - What makes your technology unique?
 - How is the Intellectual Property proteted?
- Product:
 - Is it developed beyond the design phase?
 - How does it scale?
 - How does your bill of materials (BOM) change with production volumes?
- Market:
 - Do you understand the market?
 - How do you plan to access the market?
 - How big is the market?
 - What market share are you targeting?
- Sales:
 - Describe your customer. Can you give references?
 - What are their problems and how do your provide solutions?
 - How are your sales distributed over the customers?
 - What kind of sales process do you have? Direct vs distributed sales? Do you have salespeople with experience, a trustworthy pipeline, good lead customers?
 - Do you have a ROI model for your client, or do you deliver a nice-to-have product?
- Economics:
 - Do you understand the big trends?
 - Does your product serve a long-term goal, service a need?
 - How does your product fit the big changing trands?
- Financials:
 - Do you have a storng and robust business plan?
 - Do you understand you future cash flow?
 - Do you understand the risks?
 - What are the sensitivities? Worst case scenario?
 - Do you have a fallback/plan-B?

Also ask the investors what their interests and terms are.

NDA - Non-Disclosure Agreement If the introduction round is finished successfully a Non-Disclosure Agreement (NDA) is signed between the investor and the founders. This is a legal contract that outlines the use of confidential material, knowledge and information that the parties wish to exchange. After the NDA is signed by both parties, access is given to the data room.

Term sheet / 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 and LOI are very similar in content, but TS is structured as a list, often in a 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. Topics are:

- Valuation of the company
- Amount of investment
- Use of proceeds
- Cap table
- Share preferences
- Governance (Board composition and chair)
- Investor commitment
- Management commitment
- Exit (right of first refusal)
- Description of the Due Diligence process (time, topics,...)
- Exclusivity

Exclusivity Legal binding clause of the LOI or TS. Caveat: Transfers a lot of control to the investor, he/she will be the only party taking the next step in the process, he/she can take advantage of the 'sunk cost effect', often exclusivity periods are extended. When giving 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 him/her dominant.

Due diligence After the Term Sheet and/or the Letter of Intent are signed, the Due Diligence process is started. This is supposed to take only up to six weeks, in reality, it will turn out to be many months. Now, the external advisors enter the arena.

- Business lawyers: will examine all the contracts in the data room.
- IP lawyers: will study the strengths of the patents of the company and the 'freedom to operate'
- External auditor: will validate the accounting, finance statements, balance sheet, taxes
- Technological consultant: may analyze the product development and the strength and relevance of the technology with respect to other solutions.

Investors themselves will:

- Do reference checks of clients, founders, key personnel.
- Analyze the commercial viability of the product and the sales process and tools.
- Study the quality of the sales pipeline.
- Based on that will make their own forecast of future sales.
- And a forecast of future cashflows.

Based on the results of the due diligence, the investors will challenge the business plan. This will allow them to:

- Create base-case and worst-case scenarios of cash burn
- Check the investment amount and the use of proceeds with respect to these scenarios, are the founders asking too much, too little?
- Assess the risk of their investment.

- Set goals, milestones for the Management
- Find the gaps, see where the company needs further support
- Check, whether some of these gaps are a no-go
- Possibly discuss releasing the invested amount in tranches, each time when a certain milestone is reached.
- Make their own valuation of the company.

3 Introduction to company valuation

There are three key financial statements: the balance sheet, the income statement and the statement of cash flow. We will give three approaches towards valuation:

- Balance sheet: Static/snapshot: $\text{Equity} = \text{Assets} - \text{Liabilities}$
- P&L: Relative value: using multiples and metrics from the Profit and Loss account (net income, EBITDA, EBIT)
- Discounted cash flow: Absolute value: using the cash flows that will be generated by the business to calculate the Net Present Value of the business - like the valuation of a bond.

3.1 Balance Sheet

Enterprise Value is the price to acquire the whole company, the shares, the debt but also receiving the cash.
 $\text{EV} = \text{Equity} + \text{Debt} - \text{Cash}$

Equity Value is the price to acquire only the shares of a company.

EV valuation will give you the price to take over the whole business including cash and debt, Equity will give you the price to buy the shares.

Tangible vs. Intangible Assets Tangible Assets are: Cash, Furniture, Plant and Machinery, Vehicles, Building, Stock, Equipment, Computers,...

Intangible Assets are: Patents, Logo, Copyright, Brand Value, Self-developed softwares, customer data, Trademark, Goodwill.

Taxi example See Lecture from 10.03.2021

| ASSETS = LIABILITIES + EQUITY | |
|--------------------------------|---------------------------------|
| BALANCE SHEET | |
| ASSETS | LIABILITIES |
| Cash: 25 kCHF | Bank loan: 160 kCHF |
| 5 cars Tesla model 3: 160 kCHF | EQUITY |
| | Contribution of owners: 20 kCHF |
| | Past earnings : 5 kCHF |

- You made a profit of 5 kCHF, you paid down 20% of the bank loan (with cash generated from the business) and the cars lost 20% in value (linear depreciation).
- Your ROE (Return on Equity) is 25%, you did very well! But your financial leverage (Debt-to-Equity) is 6.4 (160/25), which is very high
- Now the value of the company is 25 kCHF that is the amount you put in there 20 kCHF + the retained earnings 5 kCHF

However, leverage increases your risk proportionally.

Banking Before the financial crisis in 2007/2008 Banks had really high leverage. It can lead to a domino effect: if one big bank goes bankrupt, others may suffer as well resulting in the economy to collapse.

3.2 P & L - Profit and Loss

Income Statement A Profit and Loss statement, or also called Income statement, summarizes the revenues, costs and expenses incurred during a specified period, usually a fiscal quarter or year. It provides information about a company's ability or inability to generate profit by increasing revenue, reducing costs or both.

Different Components of P & L

- Revenues (sales) = income per hour * operating hours per year * occupancy rate * fleet size
- Costs of goods sold = cost of the material and labor directly used to run the business. COGS = operating hours per year * fleet size * (costs per hour for the driver + operating costs * occupancy rate)

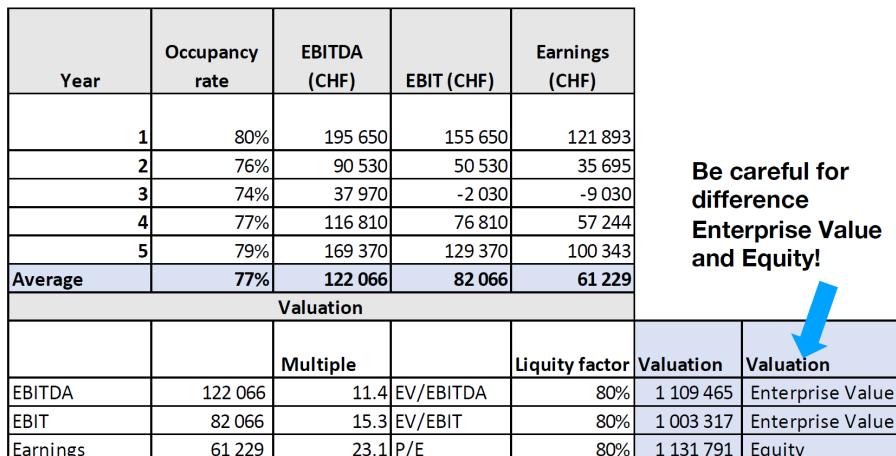
- Gross Margin = Revenue - COGS
- OPEX = Operating Expenses (the remaining costs that are not included in COGS)
- EBIT = Earnings Before Interest and Taxes (Operating Profit) = Gross Margin - OPEX
- EBITDA = Earnings Before Interest, Taxes, Depreciation and Amortization = EBIT + D&A
- EBT = Earnings Before Taxes = EBIT - Interest paid
- Net Profit = EBIT - Interest paid - taxes

A company is a 'process'.

Relative valuation and the use of multiples In relative valuation, the value of an asset is deduced from the market value of a set of similar assets. To do relative valuation we need to identify comparable assets and obtain their market value and standardize these market values, because absolute prices cannot be compared. This process of standardization creates price multiples.

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.



The diagram illustrates the calculation of Enterprise Value and Equity using different valuation ratios. It shows three tables: one for financial statement data, one for calculating Enterprise Value, and one for calculating Equity.

| Year | Occupancy rate | EBITDA (CHF) | EBIT (CHF) | Earnings (CHF) |
|----------------|----------------|----------------|---------------|----------------|
| 1 | 80% | 195 650 | 155 650 | 121 893 |
| 2 | 76% | 90 530 | 50 530 | 35 695 |
| 3 | 74% | 37 970 | -2 030 | -9 030 |
| 4 | 77% | 116 810 | 76 810 | 57 244 |
| 5 | 79% | 169 370 | 129 370 | 100 343 |
| Average | 77% | 122 066 | 82 066 | 61 229 |

| Valuation | | | | | | |
|-----------|---------|----------|-----------|------------------|-----------|------------------|
| | | Multiple | | Liquidity factor | Valuation | Valuation |
| EBITDA | 122 066 | 11.4 | EV/EBITDA | 80% | 1 109 465 | Enterprise Value |
| EBIT | 82 066 | 15.3 | EV/EBIT | 80% | 1 003 317 | Enterprise Value |
| Earnings | 61 229 | 23.1 | P/E | 80% | 1 131 791 | Equity |

Be careful for difference
Enterprise Value and Equity!

- 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

3.3 Cash-Flow Statement

The Cash flow statement consists of three parts: operating activities, investing activities and financing activities.

- Operating Cash flow = Net income + Non cash expenses - increase in Working capital
 - Change in Working capital: $\Delta WC = \text{change in accounts receivable} + \text{change in inventory} - \text{change in accounts payable}$
 - There is a risk of growing too quickly. As a start up when you grow very fast, your working capital can also increase very quickly because you have to pay your vendors early because they do not trust you and otherwise they will not supply, you do not get paid by clients because they have strong negotiation power or you have to increase your inventory. As a consequence you can get in serious liquidity problems and even go bankrupt because you grow too fast!

- Cash Flow from Investing Activities = Purchase/Sale of Long-Term Assets (Capex) + Purchase/Sale of other businesses (M&A) + Purchase/Sale of marketable securities
- Cash Flow from Financing Activities = Issue/Repurchase equity + Issue/Repurchase Debt + Dividend Payments and other Items

| | Operating Cash Flow | | | Cash Flow from Investing Activities | Cash Flow from Financing Activities | | Cash Flow | |
|------|---------------------|-------------------|-----------------------------|-------------------------------------|-------------------------------------|---------|----------------------|---------|
| Year | Net Income | Non Cash Expenses | Increase in Working Capital | CAPEX | Equity | Debt | Total Change in Cash | Cash |
| 0 | 0 | 0 | 0 | -200 000 | 20 000 | 200 000 | 20 000 | 20 000 |
| 1 | 121 893 | 40 000 | -15 000 | 0 | 0 | -40 000 | 106 893 | 126 893 |
| 2 | 35 695 | 40 000 | -10 000 | 0 | 0 | -40 000 | 25 695 | 152 588 |
| 3 | -9 030 | 40 000 | -5 000 | 0 | 0 | -40 000 | -14 030 | 138 558 |
| 4 | 57 244 | 40 000 | 10 000 | 0 | 0 | -40 000 | 67 244 | 205 802 |
| 5 | 100 343 | 40 000 | 5 000 | 0 | 0 | -40 000 | 105 343 | 311 145 |

Figure 3: Cash flow from Taxi Business

3.4 Company Valuation

Time value of money The Formula for Future value:

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

with FV the future value, PV the present value, n the number of periods and r the rate of return or discount rate or interest rate or growth per period.

Price of a bond

$$\text{Bond Price} = \frac{C}{(1+i)} + \frac{C}{(1+i)^2} + \dots + \frac{C}{(1+i)^n} + \frac{M}{(1+i)^n}$$

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

Bonds vs. Stocks

- Bonds:
 - Issues of debt
 - Debt that is made with an investor for cash in exchange for payouts of interest.
 - Typically traded over the counter (OTC)
 - Generally lower risk, lower reward
 - Since 1929 have earned around 6% each year
 - Can be made as corporate, municipal, or treasury bonds
- Stocks:
 - Issues of a stake of ownership in a company
 - A claim to a company's assets and earnings that often gives the investor voting rights and pays dividends
 - Typically traded through a central exchange (like NYSE)
 - Generally higher risk, higher reward
 - Since 1929 have earned around 10% each year
 - Are issued by companies at a stock exchange as IPOs

Discounted Cash Flow Valuation Present Value of Discounted Cash Flows:

$$PV = \frac{CF_1}{(1+r)^1} + \frac{CF_2}{(1+r)^2} + \cdots + \frac{CF_n}{(1+r)^n} = \sum_{i=1}^{\infty} \frac{CF_i}{(1+r)^i} = \sum_{i=1}^{\infty} \frac{CF_0[1+g]^i}{(1+r)^i} = CF_0 r' \sum_{i=0}^{\infty} r'^i = CF_0 \frac{r'}{1-r'}$$

with $r' = \frac{1+g}{1+r}$, CF the cash flow for a period, r the discount rate and n the 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 $n = \infty$
- 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, higher risk will be high r and vice versa.

Valuing a mature business with cash flow growing steadily at g :

$$PV = CF_0 \frac{1+g}{r-g} = \frac{CF_1}{r-g} \Rightarrow \frac{PV}{CF_1} = \frac{1}{r-g} \Rightarrow r = \frac{CF_1}{PV} + g$$

- This is called the dividend discount model or the Gordon-Shapiro formula: total return is dividend yield + growth rate
- If the company is in a steady state of constant growth, the discounted cash flows formula can be written in the form of a multiple

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

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

with r the target rate of return during start-up phase and r' the target rate of return of mature business.

- We discount the estimated cash flows during the start-up phase individually
- We calculate the TV (Terminal Value) of the company 5 years in the future, when it has reached a state of maturity growth.
- We discount this TV
- This is like pricing a bond with estimated coupons and an estimated notional value

Discount rate

- Cashflows are discounted at a target rate of return, this is set high enough to capture business risk and the likelihood that the firm will not survive.
- Rates decrease as firms move through the life cycle and the chance of failure drops.

| Stage of development | Typical target rates of return |
|----------------------|--------------------------------|
| Start up | 50% – 70% |
| First stage | 40% – 60% |
| Second stage | 35% – 50% |
| Bridge / IPO | 25% – 35% |

Table 1: Venture capital target rates of return - Stage in Life Cycle

| | 3 years | 5 years | 10 years | 20 years |
|----------------|---------|---------|----------|----------|
| Early/Seed VC | 4.90% | 5.00% | 32.90% | 21.40% |
| Balanced VC | 10.80% | 11.90% | 14.40% | 14.70% |
| Later Stage VC | 12.40% | 11.10% | 8.50% | 14.50% |
| All VC | 8.50% | 8.80% | 16.60% | 16.90% |
| NASDAQ | 3.60% | 7.00% | 1.90% | 1.90% |
| S&P | 2.40% | 5.50% | 1.20% | 8.00% |

Table 2: Returns earned by Venture Capitalists - 2007

The actual annual returns earned by VCs at every stage of the process are much more modest. The high target rates of return that are used for discounting are not delivered because of the low survival rate.

Summary Three ways of valuation:

- The balance sheet valuation gives you the company's book value, that is its shareholders' equity (capital and reserves), or the difference between its assets and liabilities.
- This does not take into consideration the fact that a company is 'a little machine' or 'a process' that generates profit based on people (knowledge, learning, ...), processes (strategy, organisation) and stuff (assets, technology, ...)
- If you buy a company, you buy a little profit-making machine (or loss?). So it makes sense to use profit generation as a basis in the valuation. That is when you do relative valuation based on market calibrated multiples and different metrics in the P&L, e.g. EBITDA, EBIT, net profit, ...
- However, this supposes that the company is in a sort of 'steady state' or 'dynamic equilibrium'. For a growth company, earnings will increase in the future and so will its valuation.
- For companies that are structured for growth, the discounted cash flow approach is needed (however, here a new parameter enters the equation, being the discount factor).

3.5 Limits of markets, complex systems and financial bubbles

Geometric Brownian Motion

$$\frac{dP}{P} = \mu dt + \sigma dW$$

with $\frac{dP}{P}$ the percentage return over a time interval dt , μdt the drift over a time interval dt and σdW the volatility over a time interval dt . Stocks are supposed to have a constant drift, that is the return part of the equation, accompanied by random shocks, that is the risk part of the equation. The geometric brownian motion random walk implies that prices follow an exponential track decorated with noise. This is equivalent to saying that growth rates are constant, that is why market movements are mostly communicated as percentage changes and not as dollar changes.

Bubbles

- A bubble starts with a new opportunity or expectation (e.g. a groundbreaking technology)
- 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 behaviour and sentiment and no longer reflects any real underlying value.

Crash

- 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. Like a ruler held up vertically on your finger, any small disturbance could have triggered the fall.
- This mechanism is often not well understood, and a great controversy arises about the cause of the crash.

Exogenous vs. endogenous processes

- For exogenous processes cause and effect are linearly and logically connected. What is important is the trigger, e.g. for the impact of an asteroid, the state of the system is irrelevant.
- For 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 at some bifurcation points.

Complex Systems "Complex" does not simply mean "Complicated", it has a very specific meaning: A complex System consists of a large ensemble of agents, like molecules, stars, insects, mammals or even human beings. These interact, e.g. they may repel, attract or imitate each other. Having a large set of interacting agents is not enough. A system is said to be "complex", when there is "Emergence", that is when local interactions lead to global cooperation, in absence of any global orchestration. The whole is different than the sum of its parts ("More is different" is a quote by Phil Anderson). "More is different": one star does not make a galaxy; one molecule cannot freeze. Local interactions lead to global structures.

Emergence Coordination in absence of orchestration. Local interactions lead to global cooperation and self-organization.

Dynamics of human systems By imitation and internal organization groups of people may exhibit a global cooperation. Emergence appears and the mass behaves like a complex system similarly to a swarm, this is endogenous, there is no master of ceremony at work. Under such circumstances it is often quite deceptive to follow a cause-and-consequence reason, what is most important is the state of the system. Any small event can trigger a major incident.

4 Wrapping up the deal

Before we draft the legal documents, we need to agree on the most important principles of the deal:

- The amount invested, and how it will be made available (in one single payment, or in tranches dependent on milestones)
- The value of the company (with a distinction between pre- and post money valuation)
- The cap table, who owns what percentage of the company
- The Governance principles

4.1 The amount invested

In the example of Company X, we decided to invest 2M Euro's. This was our base case scenario. The investment amount turned out to be too small and follow up rounds were needed. 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. As a founder/entrepreneur, it is important 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 lower and you will dilute (start losing ownership of the company).

4.2 Value of the Company

| | DD: due diligence | D&A: depreciation and amortization | Company X - valuation after DD (1000 EUR) | | | |
|---------------------------|-------------------|------------------------------------|---|--------|--------|----------------|
| | | | 2014 | 2015 | 2016 | 2017 |
| Revenues | | | 777 | 1 666 | 5 143 | 8 620 |
| Cost of Goods Sold | | | -358 | -698 | -1 511 | -2 327 |
| Gross Margin | | | 419 | 968 | 3 632 | 6 293 |
| OPEX | | | -459 | -1 819 | -3 093 | -4 070 |
| Of which: Fixed costs | | | -445 | -1 798 | -2 956 | -3 852 |
| D&A | | | -14 | -21 | -137 | -218 |
| EBIT | | | -40 | -851 | 539 | 2 222 |
| interests | | | -9 | -16 | -17 | -18 |
| EBT | | | -49 | -867 | 522 | 2 204 |
| Taxes | | | | | -453 | 25% |
| Net profit | | | -49 | -867 | 522 | 1 752 |
| Depr | | | 14 | 21 | 137 | 218 |
| CAPEX | | | -14 | -574 | -400 | -400 |
| Change in working capital | | | -8 | -44 | -174 | -174 |
| Cash Flow | | | -57 | -1 464 | 85 | 1 396 |
| | | | 0 | 0 | 85 | 1 396 |
| | | | -57 | -1 464 | 0 | 22 224 |
| | | | | | | Terminal Value |
| | | | 0 | 0 | 0 | 0 |
| RoE | | 35% | | | | |
| DCF | | 3 889 | | | | |
| Debt | | -58 | | | | |
| Cash | | 169 | | | | |
| Pre money | | 4 000 | | | | |

AWC= Change in Accounts Receivable + Change in Inventory – Change in Accounts payable
Accounts receivable= Sum of all invoices send out to customers that have not been paid yet
Accounts payable= Sum of all invoices received from vendors that you have not paid yet

$$PV = \sum_{i=1}^4 \frac{CF_i}{(1+r)^i} + \frac{TV}{(1+r)^5}$$

In this case, we calculate the **Working Capital** as 5% of the Delta revenue, assuming that WC scales with sales (stock). Depends on the business of course

In the example of Company X, the pre money valuation was 4M EUR. The valuation is very sensitive to EV/EBIT multiple and ROE (which is used as discount factor)

Taxes: $-(49-867+522+2204)*25\% = -453$ (You only pay taxes when the cumulative EBT (Earnings before taxes) of the previous years is positive)

Depreciation is not a cash flow item, it is a loss but it is not a cash out, the cash out occurred at the time of the investment, so to go from P&L to cashflow you have to add the non-cash items again.

Figure 4: Value of the Company

| Pre-money | Ownership | Value |
|--------------|-----------|---------------|
| Founder 1 | 33.3% | EUR 1,333,333 |
| Founder 2 | 33.3% | EUR 1,333,333 |
| University | 33.3% | EUR 1,333,333 |
| Total | | EUR 4,000,000 |

| Post-money | Ownership | Value |
|--------------|-----------|---------------|
| Investor | 33.3% | EUR 2,000,000 |
| Founder 1 | 22.2% | EUR 1,333,333 |
| Founder 2 | 22.2% | EUR 1,333,333 |
| University | 22.2% | EUR 1,333,333 |
| Total | | EUR 6,000,000 |

With this new investment, the initial owners get diluted by 2/3, that is the pre-money valuation of 4M / post-money valuation of 6M.

So, 1/3 in ownership becomes 2/9

Figure 5: Pre- and Post money

4.3 Cap Table

Capitalization Table: Specifying ownerships, equity value, etc.

4.3.1 Governance principles

What?: To outline the responsibility, the composition and the authority (the decisions making process) of the Management Team (MT), the Supervisory Board (SVB) and the General Meeting of Shareholders (GMS) of the 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 article of association and/or the shareholder agreement, where needed.

4.3.2 Corporate Bodies

Consists of three parts: General Meeting of Shareholders, Supervisory Board, Management Team.

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 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 or 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.

Supervisory Board, Typical decision authority of the board

- Hire/fire of senior management
- Adoption and/or amendment of yearly business plan and budget
- Investment, 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.

General meeting of Shareholders, Typical decision authority of shareholders:

- issue of new shares
- hire/fire new CEO
- distribution of dividends
- Reorganisation of the business
- Application for bankruptcy
- Debt restructuring
- Acquisition of another company
- Sale to - or merger with another company
- ...

4.3.3 Legal Documents

Once the amount invested, the value of the company, the cap table, and the governance principles are agreed upon, the legal documents are drafted. The main documents are the following:

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

When everything goes fine, these documents will never be read again after signing at the notary office. But remember that they are written for when things go wrong e.g. in business, but also in private life or health... So one important part of the legal documents is to prescribe how a 'divorce' between different parties can be arranged!

Subscription Agreement

- A Subscription Agreement is between a company and private investor to sell a specific number of shares at a specific price.
- It contains, amongst others, information regarding the amount invested, the cap table, issues 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 (the so-called '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 Management Team (MT), the Supervisory Board (SVB) and the General Meeting of Shareholders (GMS) of the company.
- Describes the exit scenario (transfer of shares) with specific care for the rights of minority as well as majority shareholders.

EXIT / Transfer of shares

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 shareholders)

- Tag along rights are 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.
- The minority shareholder then 'tags along' with the majority shareholder's sale.

Good leaver / Bad leaver 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 serious 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.

Management Agreement (day-to-day operations)

Agreement between the management and the company outlining.

- Exchange management services
- Management fee
- Variable remuneration (bonus)

- Targets and objectives
- Duration and termination of the contract
- Intellectual property rights
- Non-competition
- Confidentiality

4.3.4 Negotiation

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.

4.3.5 Signing at the notary office

The final step is to sign the contract at the notary office.

5 The logistic equation of growth, saturation and diffusion

5.1 The logistic equation

Growth and saturation in an environment with competition for limited resources. The size of a population, with competition for limited resources, grows according to a very specific process. It has an *S*-shape.

5.1.1 Mathematical formulation

Logistic differential equation:

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

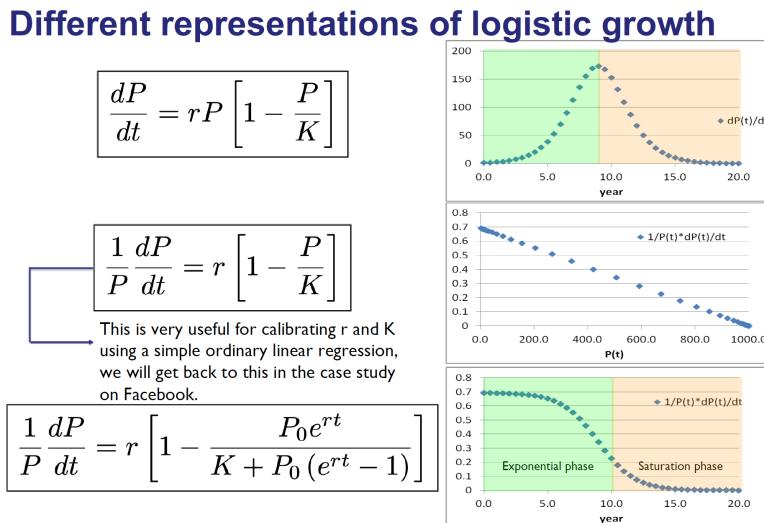
In the beginning ($P(t) \ll K$), for small t , we have exponential growth. Later $P(t)$ plateaus and reaches the constant value of K .

5.1.2 Mathematical solution

With P_0 the initial population ($P(t=0) = P_0$). The solution, called logistic function, is:

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

5.1.3 Different representations of logistic growth



5.1.4 The Hubbert model and peak oil

Oil production rates, in Gb/Year (billion barrels per year) were modelled using the following equation:

$$\frac{dP}{dt} = \frac{A}{1 + \cosh[-B(t - C)]} \Rightarrow P(t) = \frac{2A}{B} \frac{1}{1 + e^{-B(t-C)}}$$

This is equivalent to the logistic equation, or that we referred to as the Varhulst Growth Model, with

$$K = \frac{2A}{B}, \quad r = B, \quad P_0 = \frac{K}{1 + e^{BC}}$$

5.1.5 Two types of models to describe epidemics

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. Emphasize the reproducibility 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 spatial temporal evolution of a set of variables and are useful to evaluate the emergent behaviour of the system across the relevant space of parameters.

5.1.6 Population growth - Exponential

- Population increases in proportion to their size
- E.g. at a 10% annual rate if increase
 - a population of 100 adds 10 individuals in one year
 - a population of 1000 adds 100 individuals in one year
- Allowed to grow unchecked, populations growing at a constant rate will rapidly approach infinity.
- This is known as exponential growth $C_t = C_0 e^{rt}$ where C_t is the population size, r is the instantaneous (per capita) rate of increase and t is time.

5.1.7 Generalized growth model

We can relax the assumption of exponential growth via "scaling of growth" parameter p :

$$\frac{dC}{dt} = rC^p(t)$$

where $\frac{dC}{dt}$ describes the incidence growth phase over time t , the solution $C(t)$ describes the cumulative number of cases at t .

- $p = 0$: this equation describes constant incidence over time and cumulative number of cases grows linearly.
- $p = 1$: well-known exponential growth model.
- $0 < p < 1$: sub-exponential (e.g. polynomial) growth patterns.
- $1 < p$: super exponential growth leading to finite-time singularity.

5.1.8 Extension of Logistic type model

- Generalized-logistic growth model (GLM):

$$\frac{dC}{dt} = rC^p \left(1 - \frac{C}{K}\right)$$

- Richards model:

$$\frac{dC}{dt} = rC \left(1 - \left(\frac{C}{K}\right)^\alpha\right)$$

- Generalized Richards model (GRM):

$$\frac{dC}{dt} = rC^p \left(1 - \left(\frac{C}{K}\right)^\alpha\right)$$

- The two additional parameters introduced:

- Parameter $p \in [0, 1]$, describes the "scaling of growth" as in the generalized growth model and allows for sub-exponential growth during the early stage of the growth.
- Parameter $\alpha \geq 0$ measures the extent of deviation from the S-shaped dynamics of classical logistic growth model. Controls asymmetry.

5.2 Generalized logistic growth modeling of the Covid-19 outbreak

Plots can be seen in the Lecture slides of Lecture 5.

Four phases of the outbreak in mainland China

| Phase | Government reaction | Major government events | Information from data |
|---|---|--|--|
| Phase I (Jan 19 – Jan 24, 6 days) early stage outbreak reflecting the situation before Jan 20 | Before Jan 20, no or limited counter measures After Jan 20, strong measures introduced | Jan 19, Guangdong declared the first confirmed case outside Hubei in mainland China Jan 20, with the speech of President Xi, all provinces started to react. Jan 23, lockdown of Wuhan | As of Jan 24, 28 provinces reported confirmed cases with daily growth rates ranging from 50% to more than 100%. |
| Phase II (Jan 25 – Feb 1, 8 days) fast growth phase approaching the peak of the incidence curve (inflection point) | Escalated government measures | The top-level public health emergency state declared by 20+ provinces by Jan 25 Jan 25, the first day of the Chinese New Year, President Xi organized the standing committee meeting to deploy the battle against the virus outbreak. | The growth rate in all provinces declined from 50% to 10%+, with an exponentially decay rate of 0.157 for the aggregated data |
| Phase III (Feb 2 – Feb 14, 13 days) slow growth phase approaching the end of the outbreak | Strict measures continued | Feb 3, end of extended Chinese new year holidays Feb 10, companies start to resume work (remotely) | The growth rate declined exponentially with similar rates as in Phase II As of Feb 14, 23 out of 30 provinces have less than 10 new cases per day. |
| Phase IV (Feb 15 – 8 March) the end of the outbreak | Gradual mitigate the strict measures | Feb 17, most companies resume work | The growth rate at the aggregate level decreased faster with exponent of 0.277. As of Feb 21, 28 provinces achieved 5-day average growth rates less than 1% |

- For countries in the early or middle stage of the outbreak, GRM is too flexible. Thus we consider the three simpler models with fewer parameters: the classical Logistic growing model, the Generalized-logistic growth model (GLM), and the generalized growth model.
- The classical Logistic growing model and Generalized-logistic growth model (GLM) tend to underestimate the number of infected cases, and the generalized growth model tend to overestimate the number of cases, which nicely serve as positive and negative scenarios for the future developments.

South Korea approach

- Korea doesn't have a tech solution, they have a solution that uses tech. It's different. When it comes to contact tracing, Korea didn't reinvent the wheel. They just used technology to dramatically speed it up. The Korean system allowed them to trace contacts in as little as 10 minutes, which is unheard of. It's like everyone else is on bicycles and Korea has a bullet train.
- Everyone's talking about apps. Get everyone to install an app and, boom, contact tracing. That's not how it works. Korea did not rely on an app for contact tracing. Instead of an app, they used a wide constellation of data a board, redundant set of data combed over by trained people.
- One key insight is speed. All of their technology, all of their bureaucracy is just there to make their response as fast and aggressive as possible. That's the only way to beat an exponential disease.

Summary

- Ultimately, the Covid-19 pandemic is a low-level stressor (anyone can imagine much worse stressors) BUT the consequences will be severe and disproportionate due to the mismanagement and unbalanced monodimensional responses.

- The guiding principle of our time: CYA (cover your ass) (active throughout time but now in "hyper-drive") Hyper-judicialization (appearing to save lives now is what counts)
- CYA explains the response of governments, Italy following China, and the rest of Europe (except Sweden) following Italy.
- In a society that aims at the mirage of "zero risk", lack of courage to follow a course of action and management based on scientific knowledge.
- Developing real-time research to inform decisions is like trying to develop GPS in the time of the sextant. Research takes time.
- ⇒ considerable increase of uncertainties catalyzed by normal conflicts between scientists.
- This amounts to a devastating failure of leadership and courage.

5.3 Generalization of logistic equations

Observation: many systems exhibit succession of *S*-curves because advances in technology etc. increase the carrying capacity K .

Idea: include this into the logistic equation with a population dependent carrying capacity with delay time τ .

$$\begin{aligned} \frac{dP}{dt} &= rP(t) \left[1 - \frac{P(t)}{K(t)} \right] \quad \text{with} \quad K(t) = A + BP(t - \tau) \\ \Rightarrow \frac{dx}{dt} &= x(t) - \frac{x^2(t)}{a + bx(t - \tau)} \end{aligned}$$

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

5.3.1 Generalized logistic growth equation

$$\frac{dx}{dt} = \underbrace{x(t)}_{\text{individual growth/gain term}} - \underbrace{\frac{x^2(t)}{a + bx(t - \tau)}}_{\text{competition term}}$$

Solution: the solution space is extremely rich and can be categorised according to a and b . Four possible scenarios:

$$\begin{aligned} \frac{dx}{dt} &= x(t) - \frac{x^2(t)}{a + bx(t - \tau)} && \text{(gain and competition)} \\ \frac{dx}{dt} &= x(t) + \frac{x^2(t)}{a + bx(t - \tau)} && \text{(gain and cooperation)} \\ \frac{dx}{dt} &= -x(t) - \frac{x^2(t)}{a + bx(t - \tau)} && \text{(loss and competition)} \\ \frac{dx}{dt} &= -x(t) + \frac{x^2(t)}{a + bx(t - \tau)} && \text{(loss and cooperation)} \end{aligned}$$

5.3.2 Nonlinear carrying capacity

Idea: instead of a linearly growing carrying capacity, consider the case of exponential growth:

$$\begin{aligned} \frac{dx}{dt} &= \sigma_1 x(t) - \sigma_2 \frac{x^2}{y(x)} \quad \text{with} \quad y(x) = \exp(bx(t - \tau)) \\ \Rightarrow \frac{dx}{dt} &= \sigma_1 x(t) - \sigma_2 x^2(t) e^{-bx(t-\tau)} \end{aligned}$$

We can distinguish 4 cases:

$$\begin{array}{ll} \sigma_1 = 1, \sigma_2 = 1 & \text{gain and competition} \\ \sigma_1 = -1, \sigma_2 = -1 & \text{loss and cooperation} \\ \sigma_1 = -1, \sigma_2 = 1 & \text{loss and competition} \\ \sigma_1 = 1, \sigma_2 = -1 & \text{gain and cooperation} \end{array}$$

5.3.3 Coupled logistic equations

Idea: instead of only one species, we can also have two interacting species x and z .

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

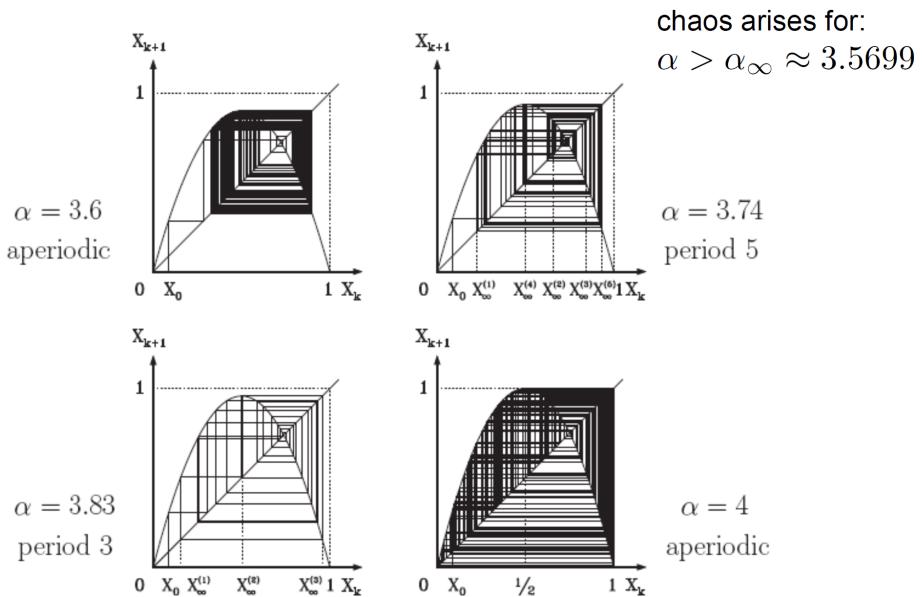
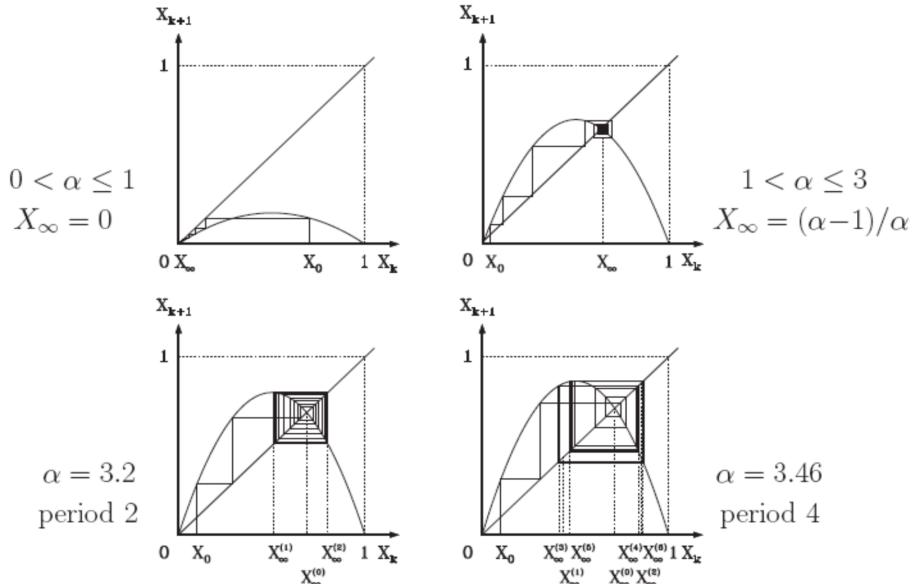
5.4 Introduction to Chaos Theory

5.4.1 The logistic map

The logistic map is defined by

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

It can be shown that x is chaotic for (almost all) values $\alpha \in [3.569 \dots, 4]$. It can be shown that the logistic map is nothing but a discretised version of the logistic equation with $\alpha = r + 1$.



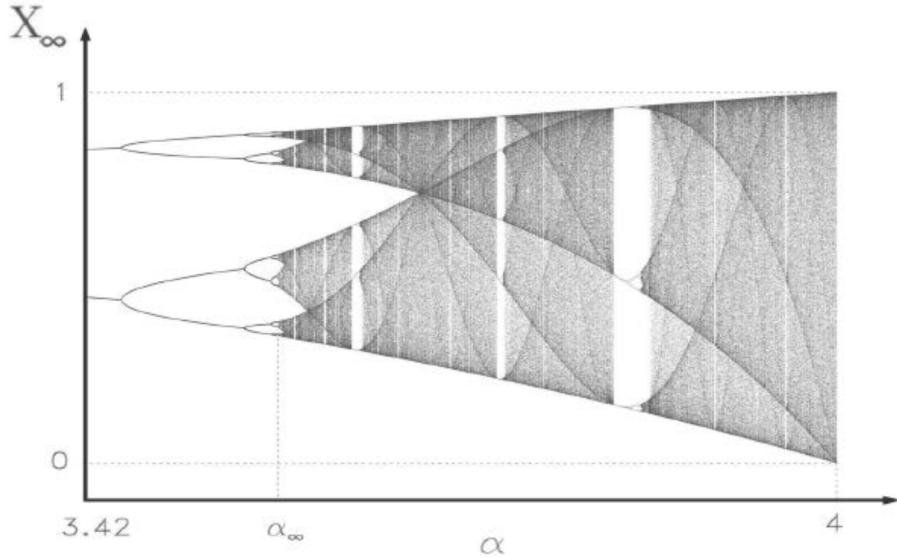


Figure 6: Bifurcation diagram

Bifurcation diagram After α_∞ , dusty "strange attractors" are common expansion of periodic buds gives small copies of tree!

5.4.2 Number Theory: roots of randomness

It can be shown that the logistic map is equivalent to the tent map

$$y(n+1) = 2y(n) \mod 1$$

with $x_n = \sin^2(2\pi y_n)$ and $\alpha = 4$. This explains the origin of the chaotic behaviour as fundamentally embedded the mathematical properties of the digits of irrational numbers, which are of measure 1 among real numbers.

5.4.3 Chaos

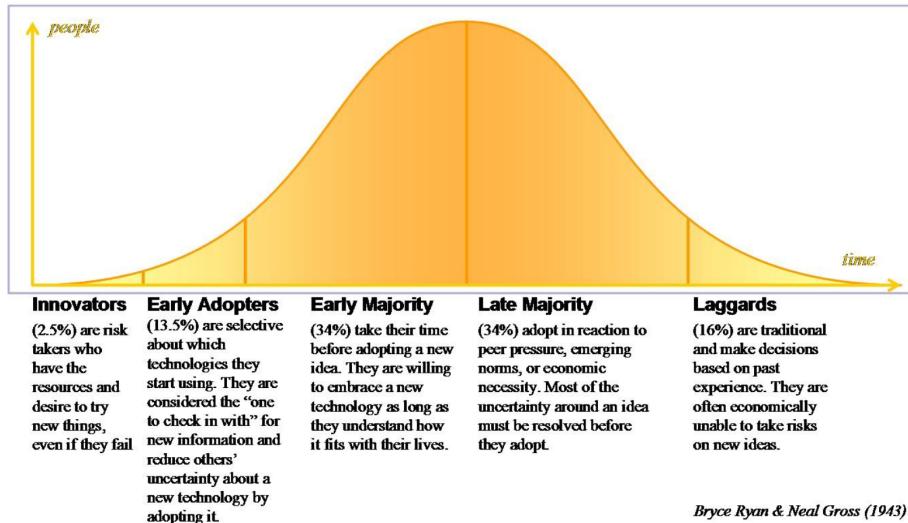
Definition Chaos is not random, but due to a deterministic map $x : A \rightarrow B$ satisfying the following properties:

1. x is low dimensional
 - x is only dependent on a "small" number of variables, for instance: $x(n+1) = f(x(n), x(n-1), x(n-2))$. Nevertheless, the outcome is very complex!
2. x is deterministic
 - This means, that the next value can always be predicted exactly.
3. x is sensitive to initial values
 - Slight changes in the initial value can dramatically change the output.
4. trajectories of x are reinjected
 - 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 arbitrarily close to each other.

5.5 The diffusion of innovation

Focus questions: How does a new technology spread? How are new products adopted by people in society?

Categories of adoption There are five different categories:



Terminology

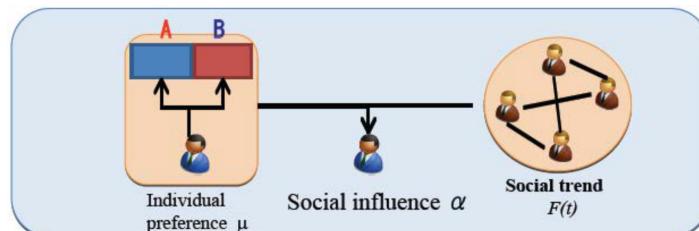
Penetration rate: The penetration rate is like the population size in Part I, it follows an S-shaped curve and saturates at 100% when the full population has adopted the new technology.

Penetration speed: The penetration speed is comparable to the production rate, it follows a Gaussian shaped curve.

5.5.1 The Agent Based Model (ABM) of Namatame

Definitions

- $F(t)$ is the penetration rate, it is the fraction of the population that has adopted the new technology, this will follow an S-shaped curve, it is cumulative.
- $F(t+1) - F(t)$ is the penetration speed, it is the fraction of the population that adopts the new technology in the following time-step, this will follow a Gaussian-shaped curve.
- $p(t+1)$ gives the probability that an agent will adopt the new technology in the next time-step.



Probability of choosing A at time t

$$p(t+1) = (1 - \alpha)\mu + \alpha F(t) \quad F(t) = A(t)/\{A(t) + B(t)\}$$

preference social trend

F(t): the proportion of the agents to choose A

$\alpha \in [0, 1]$: social influence factor

The Model

- $p(t+1) = (1-\alpha)\mu + \alpha F(t)$. The first term corresponds to personal preferences (is a constant) and the second term corresponds to the social trend (A fraction of the penetration rate, the social trend increases as more people adapt).
- $p(t+1)$ only applies to agents that have not yet adopted, this concerns the fraction $(1-F(t))$ of the agents.
- 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 times the number of non-adapted agents.
- $F(t+1) = F(t) + p(t+1) \cdot (1-F(t)) = F(t) + ((1-\alpha) \cdot \mu + \alpha \cdot F(t)) \cdot (1-F(t))$
- In case there is no personal preference and only social interaction:
 - $\mu = 0$
 - $F(t+1) = F(t) + \alpha \cdot F(t) \cdot (1-F(t))$
 - In continuous form:
 - * $\frac{dF(t)}{dt} = \alpha \cdot F(t) \cdot (1-F(t))$
 - * This is the logistic differential equation with $K = 1$
 - * 100% penetration rate agrees with a carrying capacity of 1
 - * $r = \alpha$
- In the case there is only personal preference, and no social interaction or context:
 - $\alpha = 0$
 - $F(t+1) = F(t) + \mu \cdot (1-F(t))$
 - continuous form:
 - * $\frac{dF(t)}{dt} = \mu \cdot (1-F(t))$
 - * $F(t) = 1 - \exp(-\mu \cdot t)$
 - This is like radioactive decay, the concentration of the parent nuclei drops exponentially and the concentration of the daughter nuclei increases with $1 - \exp$. Indeed there is no interaction between the nuclei in radioactive decay.
- The penetration rate differs for different levels of social interaction and varies between a process without any social interaction, like nuclear decay, and a process with a very strong social interaction, like the growth of rabbits.

Example: Diffusion of innovation Penetration rate as a function of time, more like a step function means more social interaction, or more trendy products. If the diffusion speed is parabolic, there is social interaction and if it is linear, there is no social interaction.

5.6 Case Study - the valuation of the company Facebook before the IPO

Analysis: see Lecture slides of Lecture 6 on 14/04/2021.¹

Greenshoe option

- A greenshoe option is also called an over-allotment option:
- At the IPO, the underwriters sold 15% more shares than what was initially targeted, creating a big short position (2.4 billion USD)
- 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.

¹<https://xyotta.com/cfiles/1186>

- 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.

Putting aside the fact that Facebook was hugely overvalued (and was for a long time), reports about reduction of revenues estimates were withheld before the IPO from retail investors. Instead of decreasing the price of the IPO in view of the worse financials, the price was increased from 28\$-35\$ to 34\$-38\$. The IPO was at 38\$. Instead of decreasing the volume of the IPO, it was increased from 337 million shares to 421 million (+25%). It was hoped that the deal could be shoved down the throat of retail investors who would buy it because of the brand name. It didn't work, they went a bridge too far.

5.6.1 Ex-ante prediction

- On the long term, the market price should converge to the fundamental one.
- This is not necessarily true on the short term: the market can stay crazy longer than you can stay solvent...
- Predictions made were correct due to two main events:
 1. A quarterly financial report was coming out on April 26th. From our fundamental analysis, we knew that the revenues were saturating. We therefore expected a downward move in price following the results.
 2. On April 30th, the lock-up period expired, adding 115 million shares to the 150 million shares already on the market. We expected the overvaluation of Zynga to be reflected in its market price as soon as insiders, better informed about the fundamental of their company, would begin to trade.
- This gave rise to a trading strategy based on 3 legs:
 1. From the time of writing (April 16, 2012) the announcement of the financial results (around April 26, 2012): stay out of Zynga or hedge if invested.
 2. From the day after the earnings announcement (around April 27, 2012) to the end of the first lock-up period (around April 30, 2012): if the financial results are significantly above those of the previous quarter, buy Zynga for a short-term holding period; otherwise short it.
 3. From the end of the first lock-up period (after 30 April, 2012): close all open long positions and short. Monitor the subsequent quarterly releases and the successive ends of future lock-up periods to position a strategy in the same spirit as above.

5.6.2 Conclusion

- We have developed a new methodology to compute the fundamental value of social networking companies based on the dynamics of their users' and revenues per user. Based on that, we can compute the intrinsic value of social networking companies.
- The intrinsic value is not only useful to make long term predictions. When coupled with the right information (financial report, lock-up expiration) it might enable us to make shorter term predictions. We need to test this hypothesis on a statistical basis.
- Bubbles are great for innovation and crossing capital and risk hurdles. But they are bad for capital allocation.

There are three important laws of valuation and investment:

1. Prediction is not extrapolation, understanding the underlying process. Example: the logistic function is exponential in the beginning but plateaus after the inflection point.
2. Understand the technicalities of the market and of investment banking. Example 1: the flat price 38 was a clear signal that the price was artificially supported by the testosterone of the greenshoe. Example 2: who are the buyers/sellers? The retail IPO was an attempt to sell the brand and shovel the deal down the throat of the users.
3. Always RTFM - Read the fucking Manual! Example: When does the lock-up period end? The moment when the insiders can start selling?

6 A 150 years perspective on society, economy and technology

Five distinct time periods

1. The 'Gilded Age' from 1870 until 1910
2. The 'First Shift' from 1911 until 1946
3. The 'Golden Age' from 1947 until 1968
4. The 'Second shift' from 1969 until 1979
5. The 'Fool's Gold Age' from 1980 until 2008-2019
6. The 'Third Shift' from 2019 to ...

Three ages Three structural regimes clearly stand out because of their specific characteristics and their very different growth drivers, we will call them:

- Gilded: Covering thinly with gold leaf or gold paint
- Golden: Made or consisting of gold, very happy and prosperous
- Fool's Gold: Pyrite's metallic luster and pale brass-yellow hue give it a superficial resemblance to gold, hence the well-known nickname of fool's gold

Shifts

- When one structural economic regime passes into another, the economic system goes through a shift.
- Because each shift experiences the end of one era and the beginning of another, it always comes with geopolitical, financial and economic disruption and distress.
- However, during these shifts, also reforms takes place, where the seeds are planted from which a new structural regime takes root.

6.1 The Gilded Age (1870 - 1910)

- Era of rapid expansion of heavy industries and infrastructure
- Accelerated innovation from the Technological Revolution led to interconnected growth: Telegraphs, railroads, transatlantic ship routes
- 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'.

Colonialism rising to its peak The combined populations of the Western European colonial powers were roughly 200 million at that time whereas more than 800 million people were living in the colonies. WW2 curtailed what was left of Western European imperial ambitions and the US, forming by itself a whole continent enjoying access to a protection from two oceans, became the new geopolitical behemoth. The end of colonialism came with the rise of the US as an empire, and the end of Western European imperial ambitions.

The first wave of globalization Infrastructure was comparable to now. You could order things on the phone and travel with and without passports. There was also a certain amount of wealth.

Inequalities were at a historical high:

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

Robber baron capitalism and winner-takes-all markets created monopolies. So the fruits of progress stayed in the hands of the happy few.

There was a high urbanization and migration.

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 → panic → 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:

- Money is linked to gold, so the standard unit of account in the economy is gold.
- Because of this, it becomes difficult for countries to 'create money' a.k.a. to 'expand the money supply to stimulate the economy'
- It 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.
- 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 restore the external balance and would attract a renewed inflow of capital (and gold) - a kind of negative feedback system.
- Gold convertibility (and fixed exchange rates) protected capital at the expense of labor. This resulted in dramatic decline in wages, rise in unemployment and a sharp rise in business and bank failures during times of crisis.

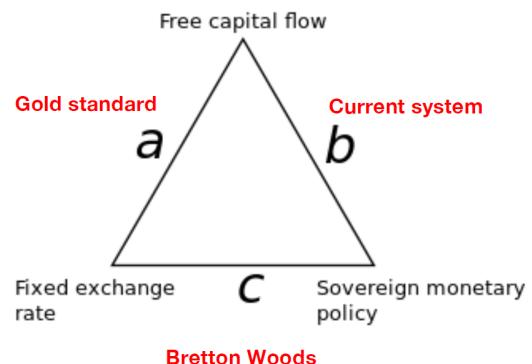
If a nation's economy were a human body, then its heart would be the central bank. And just as the heart works to pump life-giving blood through the body, the central bank pumps money in the economy to keep it healthy and growing. Sometimes economies need less money, and sometimes they need more.

At the micro-level, easy access to money means more spending, investment and consumption by people and by businesses.

6.1.1 The trilemma of international finance

Economic policy makers want to achieve three goals:

- Open their country's economy to international flows of capital or to bring in foreign capital and to allow the nation's citizens to diversify their investments abroad.
- Follow an independent monetary policy to stabilize their economy and support employment and support employment in times of need.
- Have a fixed foreign exchange rate which brings stability and trust in international trade and investment.



Suppose a government wants to fight a recession by cutting its interest rates. If capital can flow freely, this will result in a net outflow of capital in search for a higher yield. This outflow will depreciate the currency - so you cannot have a fixed exchange rate. Vice versa: If a government wants to fight inflation by increasing its interest rates. If capital can flow freely, this will result in a net inflow of capital in search for higher yield. This will increase the value of the currency. You can only have two out of three:

- Gilded Age: Fix exchange rate and let money 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.
- Fool's Gold Age: Follow independent monetary policy and let money flow freely across the globe at the expense of a fixed exchange rate.

Bretton Woods is fully top-down steered, Gold Standard is fully bottom-up laissez-faire, the current system is in the middle.

6.1.2 Shifts

- When one structural economic regime passes into another, the economic system goes through a shift.
- Because each shift experiences the end of one era and the beginning of another, it always comes with geopolitical, financial and economic disruption and distress.
- However, during these shifts, also reform takes place, where the seeds are planted from which a new structural regime takes root.

6.2 The First Shift (1911 - 1946)

The first shift was characterised by nationalism, imperialism, war, revolution, depression and genocide. There was huge unemployment.

Institutional reform with Roosevelt' New Deal (1933-1939):

- Stabilizing the banking system through bank reform acts (e.g. Glass-Steagall, establishment of the Federal Deposit Insurance Corporation - FDIC)
- Suspension of the Gold Standard, with a freely floating US Dollar and increase of money in circulation by the Federal Reserve
- Increase transparency in the stock market by mandatory publication of balance sheet, profit and loss statement...
- Public works and relief: Hire unemployed to build schools, municipal buildings, waterworks, sewers, streets, parks airports, hospitals... (Civil Works / Public Works Administration)
- Social security act establishing a permanent system of pensions, unemployment insurance, welfare benefits...

- National Labor Relations Act guaranteed workers the right to collective bargaining through unions
- Fair Labor Standard Act set maximum of 44 hours of work per week and minimum wages, child labor under 16 was forbidden
- Wealth Tax Act: redistribute wealth by imposing a tax of 79% on income over 5 million USD.

Wartime stimulus and massive capital investment during WW2:

- The number of machine tools in the US doubled between 1940 and 1945.
- Almost all of these were paid for by the government.
- Because all were state-of-the-art, they could be reconverted to produce consumer goods after the war.

High-pressure economy of WW2 with 'infinite demand', created an environment of 'Learning by doing' where everybody on all levels was eager to increase efficiency and reduce costs. This working culture, adopted during the wartime period, and the best-practices resulting from it, persisted after the war had ended. As an example, in 1942, it took 8 months to build a standard Liberty freighter ship, by the next year, this had been reduced to a few weeks.

6.2.1 Bretton Woods

In the summer of 1944 (3 weeks after D-day), 730 representatives of 44 countries gathered at the Bretton Woods conference with the ambitious goal to redesign the international monetary system, the new system should:

- replace the monetary chaos of the interwar period with a new international system that would support trade through stable exchange rates.
- Free trade was preferred to free capital flows, especially to short-term 'hot money' flows and capital flight, and as such, it was explicitly recognized that countries needed to impose capital controls.
- Each country could still follow an independent monetary policy to fight recessions and stimulate employment.

Lessons would be learned from the past, and, more specifically from the mistakes that had been made in the interbellum period where countries had re-joined and then abandoned the gold standard following a beggar-thy-neighbour strategy in a series of competitive devaluations. Protectionism had risen and economic cooperation between the great powers had vanished leading to a deepening and lengthening of the Great Depression, which pushed many countries into totalitarianism.

After the war, the idea rose to support trade through international cooperation, but still be able to fight recessions with independent monetary policy. This imposed capital controls.

After the war, "the Greenback was the only currency left standing and capable of lubricating world trade".

Bretton Woods established a system of payments based on the dollar, which defined all currencies in relation to the dollar, itself convertible into gold, and above all "as good as gold" for trade. US currency was now effectively the world currency, the standard to which every other currency was pegged.

Back to the trilemma of international finance The current system has the advantage that exchange rates can buffer an economic shock, when a currency devalues, exports from that country become very cheap. This is an alternative to devaluation through wage decreases. However, free flow of capital creates flows of 'hot money'... see crises of 1994 and 1997.

Lessons learned From the calamities during the first shift, lessons were learned from which the Golden Age would rise:

- Institutions were reformed to fight the Great Depression.
- A social welfare system was installed to counter the upcoming Bolshevik revolution.
- WW2 led to massive stimulus and capital investment.
- To fight nationalism, and support trade in a balanced way, the international financial system of Bretton Woods was set up.

6.3 The Golden Age (1947 - 1968)

The two decades after WW2 were blessed with extraordinary economic growth:

- Mean reversion: Recovery of the economy to its full potential after WW2.
- Stimulus: reconstruction of infrastructure and industry
- Productivity increase from technical innovations and capital investments

A social contract between workers and owners on

- The parallel growth of real wages and productivity
- ensuring that the fruits of the economic progress were equitably shared
- Led to wealth accumulation and spare time ⇒ CONSUMERISM

Inequality from the stone age to the 21st century "Thousands of years of history boil down to a simple truth: ever since the dawn of civilization, ongoing advances in economic capacity and state building favoured growing inequality but did little if anything to bring it under control." Inequality will always have the natural tendency to increase, only violent ruptures have been able to flatten it:

- Mass mobilization warfare
- Transformative revolution
- State failure
- Lethal pandemics

Consumer Society Free time and wealth accumulation created a consumer society with new demand for consumer goods like electrical apparel, automobiles or entertainment services.

The Rise of hydrocarbon man During the Gilded Age, coal has been the primary energy source. During the Golden Age, Oil and Natural Gas have been added to mix and taken up a bigger proportion. The West became very much dependent on fossil fuels.

The Fall "The Great Society rests on abundance and liberty for all. It demands an end to poverty and racial injustice... The Great Society is a place where every child can find knowledge to enrich his mind and to enlarge his talents... It is a place where the city of man serves not only the needs of the body and the demands of commerce but the desire for beauty and the hunger for community." changed to "Things fall apart, the center cannot hold. Mere anarchy is loosed upon the world..." Anarchy and countercultures emerged.

6.4 The Second Shift (1969 - 1979)

The Nixon shock and the end of Bretton Woods (1971)

- The Bretton Woods system was based on trust in the US Dollar.
- But the US overstretched in a Vietnam war combined with rising public expenditures in the Great Society programs
- At a certain point there were more dollars in the hand of foreign countries (so-called eurodollars) than the total gold stock of the US
- Trust in the US Dollar, which was the keystone of the Bretton Woods system, evaporated
- In February 1965, President Charles de Gaulle sent the French Navy across the Atlantic to pick up the French reserve of gold, a gesture which was soon followed by other countries.

As long as the US had a trade surplus, all the dollars it was sending out, came back. When reversed, the Eurodollar pool became a lake and a sea. The world was awash with dollars that were all supposed to be backed by Gold.

- The US gold reserves, which were at 65% of the world monetary stock in 1952, reduced to 29% in 1967, 15 later.
- The opposite happened in Europe, where the combined gold reserves of France, Germany and the UK were at 6% of global stock in 1952, increasing to 26% in 1967.
- This dynamic ended on August 15, 1971, with the 'Nixon Shock', when the US President Richard Nixon unilaterally ended the convertibility of the Dollar to gold. This was the end of the Bretton Woods system.

Peak Consumption You can only buy a limited amount of stuff, technology adoption follows the S-shape of the logistic growth process, where the strongest growth rate can be observed during the Golden Age.

Economic paradigm shift from falling unemployment with rising inflation, to stagflation. Fiscal and monetary overstretching because of Lyndon Johnson's Great Society and the Vietnam war.

Philips' Relation Intuition: A falling unemployment rate signals an increase in the demand for labor, which puts upward pressure on wages. Profit-maximizing firms then raise the price of their products in response to rising labor costs.

From the end of the fifties, throughout the sixties, many economists were convinced that there was a fundamental and permanent relationship between inflation and unemployment. It was conjectured that the process underlying this 'law of nature' was based on a virtuous cycle where higher demand for goods would increase prices, which in turn would encourage companies to hire more personal, increasing general employment, and again driving up demand in a positive feedback loop. This relationship, called the **Phillips curve**, was one of the empirical backbones of Keynesian policy. It was believed that governments could make a trade-off between inflation and employment. Government spending and tax reductions could be used to stimulate the economy, which would have inflationary effects. However, a reasonably high level of inflation would be acceptable as this would lead to a lower unemployment through the Phillips relationship. As such, it was believed that governments could spend their way out of a recession by cutting taxes and boosting government spending. Any inflation that would come as a by-product of this policy would be politically acceptable as it would result in higher employment through the Phillips curve.

In the beginning of the 1970s, western countries started losing their grip on oil exploitation, this led to 2 oil shocks:

- First oil shock with the OPEC oil embargo as a reaction to the Yom Kippur war (1973 Arab-Israel war)
- Second oil shock with the Iranian revolution under the leadership of Ayatollah Khomeini (December 1978 / January 1979)

The most dramatic knock-on effect that would lead to the first oil shock and as such would contribute to the global power shift in oil markets, came about in October 1973, when a coalition of Arab forces, led by Egypt and Syria launched a surprise attack on Israel on the Jewish holy day of Yom Kippur, the Day of Atonement. The Yom Kippur war lasted only three weeks, featured by intense fighting with one of the most spectacular reversals in military history, when the Israelis managed to turn around a hopeless situation 'from being within hours of extinction to shattering the invading forces and advancing on Damascus and Cairo'. The fact that the Americans had supported the Israeli forces with military supplies, in a very plain and unsophisticated fashion, at crucial stages during the three-week period of hostilities, bonded the alliances within OPEC.

6.5 The Fool's Gold Age (1980 - ...)

The Illusion of the Perpetual Money Machine

- Consumption, not funded by savings but by debt, and by wealth extracted from the stock and the housing market
- Economic growth, not driven by productivity increase in the real economy, but by growth of the financial sector
- Further supported by a climate of deregulation and a massive growth in financial derivatives

- Resulting in a succession of bubbles and crashes, feeding upon each other and culminating in the GFC (Global Financial Crisis) of 2008

The ultimate financialization offered by ETFs opens the road to more bubbles created by the herding mechanism of small investors as well as large hedge funds and sovereign funds crowding in and out of the investment fashion of the moment.

Reaganomics / Thatcherism

- Decline in Representation: Decline in Union Membership
- Reagan decreased taxes of the rich to provide an incentive to save. This would increase investment and create jobs.
- The savings of the rich would 'trickle down' to the masses.

The sharp rebound in inequality in the US was mainly the result of a shift in economic policy often referred to as 'Reaganomics' or 'Thatcherism'. John Komlos, Professor Emeritus at the University of Munich, describes the ideology of that time as follows: In short, Reagan advocated decreasing the taxes of the deserving rich, which would provide incentives to increase savings and investment and thereby create jobs and subsequently 'trickle down' to the masses so they will benefit from it in due course. Moreover, lower taxes meant an increase in take-home pay and that would provide an incentive for people to work harder and for entrepreneurs to take more risk, thereby growing the economy and boosting incomes.

- The fruits of economic growth not equitably shared

Method was a bit counterproductive. The rich got very richer and the poor only got a little bit richer. The gap increased.

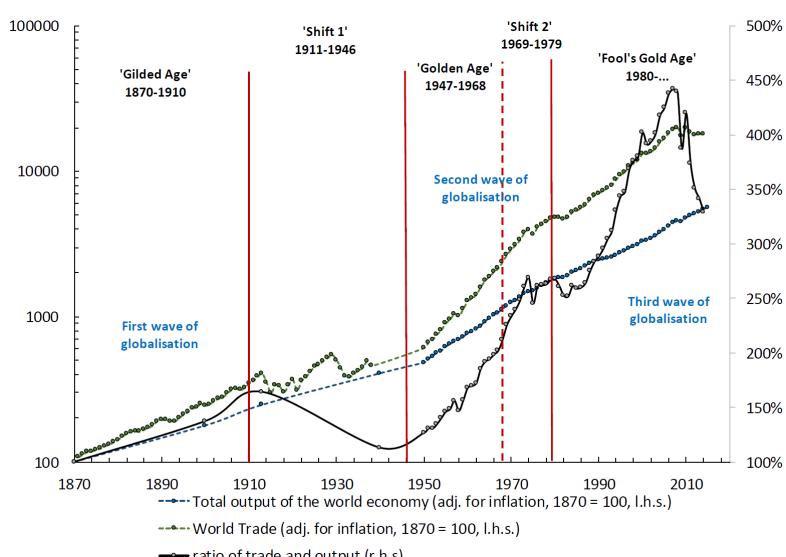
Decreasing Savings, increasing consumption based on debt Consumption was paid with debt.

Stock Markets The Fool's Gold Age was characterized by a very strong stock market performance, with lagging earnings. This strong stock market performance is not reflected in an increase in productivity. To the contrary we see a secular decline in the productivity in the West over the past 50 years.

Economic Growth There is a different picture for China. China paints a completely different picture with a very strong increase in per capita real GDP over the past 40 years.

6.5.1 Three waves of globalization

Globalization is not an inevitable process, and it is also not a linear process.



- The first wave came with the technological revolution, pushed forward by increasing connectivity, falling transportation costs and the gold standard and the Pound Sterling that create a global marketplace.
- The second wave: Renewed international cooperation and trade liberalization after nationalism during the First Shift brought globalization back to its previous level. But flows between emerging and developed markets were limited to those primary commodities that did not compete with agriculture in the developed countries.
- In the third wave, new information and communication systems made it possible to manage and control geographically dispersed supply chains. Production flowing to places with lower cost of labor.

The second vs third wave of globalization

- In the second wave of globalization, resources were extracted from developing countries. Trade flows were mainly raw materials from developing to developed countries.
- In the third wave, developing countries were integrated in the global supply chains.
- The second wave mainly favored the rich countries. During the third wave developing countries made a spectacular catch-up movement.

The Economic center of gravity is moving East The Economic gravity and light mean centre moved to the east.

Debt, Investment, Financialization and Consumption in the Fool's Gold Age

Debt Another characteristic of the Fool's Gold Age is the massive increase in debt, but the remarkable decrease in the 'efficiency of debt'. Now one dollar in the non-financial sector 'generates' 25 cents in GDP. Student loans and Car loans increased immensely.

Investment But this increasing in debt is not used to increase investment in tangible assets.

Consumption Consumption has still increased since the Golden Age, but the mix has shifted from goods to services (healthcare, pension, financial services, insurance)

Financialization Massive growth of the derivatives market up to a current level of 600 – 700 trillion USD. Rise of machines: automatic trading / high-frequency-trading.

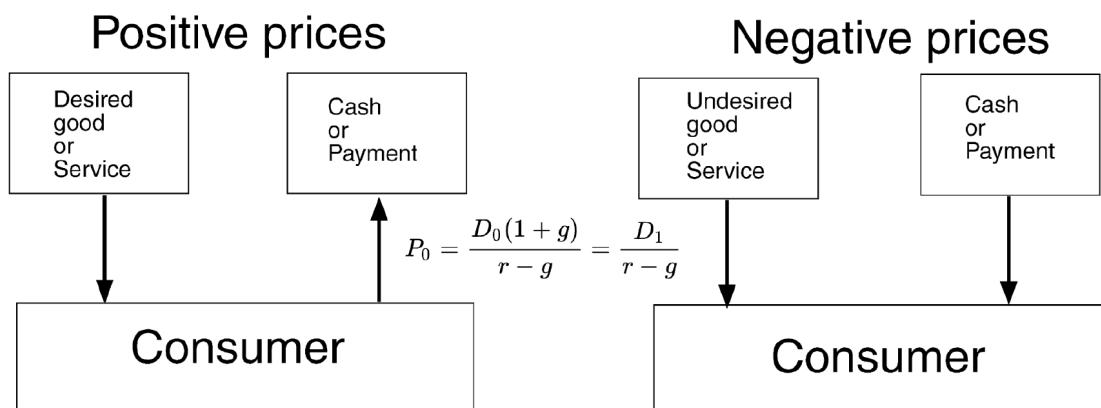
- Put simple, ETF's are funds that are traded on the stock market (ETF = Exchange Traded Funds).
- ETFs can specialize in certain investments e.g. gold, or oil, or other commodities.
- They provide a very easy access for smaller investors to specific products, or strategies.
- There are now 5 Trillion USD in ETFs outstanding.
- Massive growth of the ETF industry.

6.5.2 ETF impact example: Negative oil prices

What are oil futures?

- Futures are standardized contracts between a seller and a buyer for the delivery (of oil) at a specific time in the future.
- There are future contracts for each month in the future up to many years ahead, but the further out the less liquid the contract becomes.
- Each future contract has its own price evolution, normally, the correlation between the contracts will be high, but there may be substantial differences nevertheless.
- Producers and big consumers of oil use futures contracts to lock in a future price to buy or sell the product that they need

- If you want to invest (speculate) in the oil (commodities) market, you cannot accept physically delivery of the product, then you have to buy a future contract.
- A graph representing prices as a function of the delivery date (x-axis) is called the term structure
- If the graph is upward sloping, it is said that the market is 'in contango'
- If the graph is down sloping, it is said that the market is 'in backwardation'
- If you buy one of these futures contracts, you are obliged to buy 1000 barrels of WTI Crude Oil at the contract/delivery date.
- If you cannot accept this physical delivery, you have to 'sell' your contract in time before the settlement date.
- This can be at any price, and, as we have seen on April 21 2020, even negative prices.
- Longer term investors always sell the futures contract before the settlement date and use the proceeds to enter a new contract. If the market is in contango this results in a loss, if the market is in a backwardation it results in a profit.
- This is called 'rolling'



Cartoons showing that the sign of price is defined by the relative direction of the flux of cash or payment compared to the flux of good or service: a positive price corresponds to the more commonly experienced situation where the cash or payment flux is with a direction opposite to the flux of good or service; a negative price corresponds to the reserve situation where the cash or payment flux has the same direction as the flux of good or service.

Figure 7: Price sign

- For retail investors, future are not very convention because you need to buy 1000 units in one contract.
- That is where ETFs come in handy.
- Those are stock listed companies that e.g. for oil only buy oil futures. You can buy a share in that company on the market e.g. for the ETF USO (US oil) you can buy shares at the price of a few USD
- An ETF like USO does not want physical delivery and has to roll its positions before the settlement date.
- With the existing super-contango in oil, this resulted in a monthly loss of 33% at the end of April 2020
- Over the month of April 2020 there has been outsized inflow (3 Bn USD) in the United States Oil Fund (ETF)
- The fund has to roll its future every month and even publishes its "roll dates" (when it is selling the near month contract and buying the next month contract)
- So, between 7/04 and 13/04, 2020, USO had to 'roll' 4 Bn USD of oil futures from the front contract to the next.

- With this size, USO totally dominated the market of the front (selling) and the next month (buying) futures
- Because the flows of USO were predictable, many 'professional investors' did front running on the ETF
- Frontrunning means that they took a position ahead of a large order, taking profit from the market impact of that order.
- They knew that the front contract would go down, and the next contract would go up (relative to each other), so they shorted the front and went long the next.
- This massive short position on the front contracts had to be closed before April 21. But there were only sellers and no buyers, this resulted in a price drop of -300% on April 20.
- The market had to go in negative territory (-40 USD) to find "buyers" of the front WTI future contract.
- Negative prices were only seen in the front contract. For example, if you look at the 6M ahead contract of OCT 2020, you could see a large drop from 31 to 25, which is a 20% drawdown on the same day (but not a 300% crash).

Bubbles feeding upon each other in the Fool's Gold Age Examples: Black Monday (October 19th 1987), Dotcom Bubble (March 2000), House price bubble peaking mid-2006

The historical evolution of the S&P500 Index showing the price growing faster than an exponential up to its tipping point of 19th October 1987. The dotted and solid smooth black lines are the results of our model calculations with two different levels of nonlinearity. Reproduced from the book "Why stock markets crash" by D. Sornette

Quarterly average House Price Index in the 21 states and in the District of Columbia (DC) where Zhou and Sornette diagnosed bubble-type behaviours in June 2005 and predicted a peak in mid-2006. For comparison, the HPI has been normalized to 100 at the second quarter of 1992.

US real house prices between 1974 and 2014. Three peaks in the growth rate are immediately followed by a correction. When the growth rate itself grows, the process becomes unstable and a correction follows around the critical point embedded in the faster-than-exponential growth process.

6.5.3 Bubble of everything 2007

Stocks The historical evolution of the S&P500 index shown as dots. The dashed vertical line shows the last observation used to calibrate our model. The colored curves show different fits. It is expected that the correction occurs with 80% probability in late 2006. This indeed happened.

Oil Also crashed mid-2008.

Debt Bubble also burst.

Globalization Bubble The time series represent a proximity index of emerging markets equities and currencies, freight prices, soft commodities, base and precious metals and energy.

6.5.4 Central bank policies as slaves to the stock market

Federal fund rates are consistently cut after stocks decline. Do central banks have an unofficial mandate to support stock markets? The key question, however, is this: did it lead or lag? According to common wisdom and standard textbook arguments, a decrease of interest rates is supposed to make borrowing cheaper. This results in increasing expectations of future growth. Additionally, lower rates mean lower discount factors. The combined effect should be a boost on stock prices. In this line of reasoning, a federal funds rate decrease should lead economic growth and cause stock market prices to increase. This, anti-correlation and a lead of the Fed rate are expected.

"Primum non nocere" vs the illusion of control In the US, there is a zero-tolerance, with the objective to stop all fires. In Mexico, there is a laissez-faire policy, arguably due to weaker resources and smaller loss exposure. The results are drastically different: while Southern California has few small fires, extremely large fires are shockingly frequent; In contrast, Baja California is graced with many small and essentially no large fires. In order for the system to be resilient against catastrophic events, deadwood needs to be cleared in a natural, dynamic, self-organized way. Could this observation also be true for the economy? With the special actions that central banks have been carrying out since the crisis, are we not piling up deadwood, with the zero-tolerance practice?

Fragile banks, and fragile markets, a dry forest waiting for the spark



6.6 Conclusion

The super-business cycle - a 150 year endogenous view on economy and society We have described the three economic regimes and the two shifts of the super business cycle of the past 150 years.

It is important to stress that we view this cycle as endogenous. Boom and burst are two sides of the same coin. It is a fundamental property of capitalism to cycle through periods of optimism and pessimism. Periods of growth have the tendency to overshoot. This is naturally corrected in a phase of consolidation or even decline.

This is in stark contrast to the exogenous view, where recessions are seen as a symptom of disease, caused by some external factor that needs to be eradicated or modified for the system to be cured.

According to Hyman Minsky, capitalism has evolved, since the late nineteenth century, through a super-financial business cycle with four stages.

- Commercial
- Finance capitalism
- Managerial Welfare state capitalism
- Money manager capitalism

Commercial capitalism

- In 'Commercial Capitalism' the financial system was centered around commercial banks.

- Banks financed working capital, in the form of short-term loans, to cover operational expenditures and the purchase of materials necessary in the production process.
- Long-term investments were financed from retained profits, or from equity injected by the owners.

Finance capitalism The second industrial revolution drastically changed the system:

- With the industrialization of the production process and the need to build big infrastructure came the strong demand for the long-term finance of capital expenditure (CAPEX).
- Finance became globalized as stocks and bonds, issued to service long-term capital investment, were sold in international finance markets.
- The financial system became dominated by investment banks.

'Stability is destabilizing' (Minsky):

- In a boom, financial institutions innovate to bypass rules and regulations imposed by the supervisory authorities.
- By the 1920s, investment banks were largely devoting their efforts to financing speculation in financial assets. As such, 'financial capitalism' ended in the crash of 1929, which ultimately led to the Great Depression.

Managerial welfare capitalism

- After the 1929 crash and during the Great Depression, the pendulum swung back. The financial sector was reformed with the New Deal legislation and the federal government took up a bigger role in managing the economy.
- Following the transition period, this corresponds to the Golden Age of stable economic growth, high employment and a social contract between workers and owners which guaranteed rising wages and low or even decreasing inequality.

Again 'Stability destabilized' (Minsky):

- The absence of deep recessions and severe financial crisis encouraged innovations that increased instability.
- New Deal reforms were cut back
- The financial system was again deregulated (Glass-Steagall)

Money manager capitalism

- The Golden Age created large pools of savings (e.g. through increased prosperity, Petrodollars...)
- From this, the 'shadow banking system' was born (pension funds, asset management, mutual funds, hedge funds, sovereign wealth funds, private equity funds and university endowments)
- The 'reason for existence (raison d'être)' of this type of capitalism is to manage huge pools of capital in search of the highest return.
- The financial system no longer serves the productive economy but serves only itself; the snake bites its own tail.
- The innovation and exploration process started focusing on the financial sector itself.
- This is what we call financialization, which led to a massive growth in complex financial derivatives.

A glimpse into the future?

- The Fool's Gold Age has been ongoing for almost three to four decades.
- I think that around 2008-2019, we have transitioned into a new Shift (2020-2050)
- The new shift is characterized by many challenges.

Overview

| | Economic driver | Stage of capitalism | Stock Market | International Financial System | Monetary Policy Regime | Reserve currency | Globalization and Colonialism | Inequality |
|-----------------------------|--------------------------|-------------------------------------|--|--------------------------------|---------------------------------|---------------------------------|--|---|
| Gilded Age (1870-1910) | Technological revolution | Finance Capitalism | Long term growth in line with earnings and the economy | Gold Standard | Gold convertibility of currency | Pound Sterling (backed by Gold) | First Wave: Falling transport costs, haute finance - cusp of Western European colonialism | Rising since last levelling event (black death in 14th century) |
| First Shift (1911-1946) | War and Depression | | Losses and high volatility | | | | | Steep decline, levelling due to WWI and WWII |
| Golden Age (1947-1968) | Consumer society | Managerial Welfare State Capitalism | Very strong growth in line with earnings and the economy | Bretton Woods | Full employment | USD (backed by Gold) | Second Wave: Return to prewar state, vertical integration in Western countries - full decolonization | Great Compression |
| Second Shift (1968-1979) | Stagflation | | Decoupling of stocks and earnings | | | | | |
| Fool's Gold Age (1980- ...) | Financialization | Money Manager Capitalism | Decoupling of stocks and earnings | Dollar Debt Standard | Price stability | USD (paper money) | Third Wave: Global supply chain, cost-of-labor arbitrage | General increase - Reagonomics |

Figure 8: Overview

The future of public debt Governments are accumulating debt in an ever-increasing spiral:

- GFC (2009)
- European Debt crisis (2011)
- Covid-19 (2020) and the current multi-trillion stimulus package

On top of that there are:

- Rising pensions
- Healthcare costs
- Aging population

Towards a new definition of money, direct monetary financing or a debt jubilee? Chinese DCEP (digital currency electronic payment)

Covid-19 stimulus - how much further can this go?

- The economist: At least \$8trn of state loans and goodies have been promised to private firms in America and Europe, roughly equivalent to all their profits over the past two years. But there is still no guarantee that this mountain of money can prevent chaos.
- The FT: Total worldwide stimulus announced since 2020 comes to about \$14tn, according to the IMF, after adding various government spending packages. Such activity has given a big lift to asset prices, from stocks to junk bonds.

6.6.1 A new bipolar world with two great "empires"?

With the White House continually provoking tensions against Russia and China, the doyen of American foreign policy, Henry Kissinger, dramatically warned Washington last week to either agree to a new international system or continue pushing tensions that are leading to a situation similar to the eve of WWI.

United States of America

Key Policy Responses as of March 11, 2021

<https://www.imf.org/en/Topics/imf-and-covid19/Policy-Responses-to-COVID-19#U>

FISCAL

• On March 11, 2021, the House approved the American Rescue Plan, which provides another round of coronavirus relief with an estimated cost of \$1,844bn (about 8.8 percent of 2020 GDP). The plan focuses on investing in the public health response and providing time-bound assistance to families, communities and businesses. It extends the unemployment benefits programs (including supplemental unemployment benefits), sends direct stimulus payments of \$1,400 to eligible individuals, provides direct aid to state and local government, adds resources to the vaccination program and increases funding for school reopening.

• On December 28 President Trump signed a US \$ 868bn (about 4.1 percent of GDP) coronavirus relief and government funding bill as part of the Consolidated Appropriations Act of 2021. The Act includes enhanced unemployment benefits of US \$ 300 weekly federal enhancement in benefits through March 14, direct stimulus payments of \$600 to individuals, another round of PPP loans, resources for vaccines, testing and tracing, and funding for K-12 education.

• On August 8, President Trump issued executive orders mostly to address the expiration of certain Coronavirus reliefs provided by previous legislations. These included i) [using \\$44 billion from the Disaster Relief Fund to provide extra unemployment benefits](#); ii) [continuing student loan payment relief](#); iii) [deferring collections of employee social security payroll taxes](#); and iv) [identifying options to help renters and homeowners avoid evictions and foreclosures](#).

• US \$ 483 billion [Paycheck Protection Program and Health Care Enhancement Act](#). The legislation includes (i) US \$ 321 billion for additional forgivable Small Business Administration loans and guarantees to help small businesses that retain workers; (ii) US \$ 62 billion for the Small Business Administration to provide grants and loans to assist small businesses; (iii) US \$ 75 billion for hospitals; and (iv) US \$ 25 billion for expanding virus testing.

• An estimated US \$ 2.3 trillion (around 11% of GDP) [Coronavirus Aid, Relief and Economy Security Act \("CARES Act"\)](#). The Act includes (i) US \$ 293 billion to provide one-time tax rebates to individuals; (ii) US \$ 268 billion to expand unemployment benefits; (iii) US \$ 25 billion to provide a food safety net for the most vulnerable; (iv) US \$ 510 billion to prevent corporate bankruptcy by providing loans, guarantees, and backstopping Federal Reserve 13(3) program; (v) US \$ 349 billion in forgivable Small Business Administration loans and guarantees to help small businesses that retain workers; (vi) US \$ 100 billion for hospitals, (vii) US \$ 150 billion in transfers to state and local governments and (viii) US \$ 49.9 billion for international assistance (including SDR28 billion for the IMF's New Arrangement to Borrow).

• US \$ 8.3 billion [Coronavirus Preparedness and Response Supplemental Appropriations Act](#) and US \$ 192 billion [t..](#) They together provide around 1% of GDP for: (i) Virus testing; transfers to states for Medicaid funding; development of vaccines, therapeutics, and diagnostics; support for the Centers for Disease Control and Prevention responses. (ii) 2 weeks paid sick leave; up to 3 months emergency leave for those infected (at 2/3 pay); food assistance; transfers to states to fund expanded unemployment insurance. (iii) Expansion of Small Business Administration loan subsidies. And (iv) US \$ 1.25 billion in international assistance. In addition, federal student loan obligations have been suspended for 60 days.

MONETARY AND MACRO-FINANCIAL

• Federal funds rate were lowered by 150bp in March to 0-0.25bp. Purchase of Treasury and agency securities in the amount as needed. Expanded overnight and term repos. Lowered cost of discount window lending. Reduced existing cost of swap lines with major central banks and extended the maturity of FX operations; broadened U.S. dollar swap lines to more central banks; offered temporary repo facility for foreign and international monetary authorities.

• Federal Reserve also introduced facilities to support the flow of credit, in some cases backed by the Treasury using funds appropriated under the CARES Act. The facilities are: (i) [Commercial Paper Funding Facility](#) to facilitate the issuance of commercial paper by companies and municipal issuers; (ii) [Primary Dealer Credit Facility](#) to provide financing to the Fed's 24 primary dealers collateralized by a wide range of investment grade securities; (iii) [Money Market Mutual Fund Liquidity Facility \(MMLF\)](#) to provide loans to depository institutions to purchase assets from prime money market funds (covering highly rated asset backed commercial paper and municipal debt); (iv) [Primary Market Corporate Credit Facility](#) to purchase new bonds and loans from companies; (v) [Secondary Market Corporate Credit Facility](#) to provide liquidity for outstanding corporate bonds; (vi) [Term Asset-Backed Securities Loan Facility](#) to enable the issuance of asset-backed securities backed by student loans, auto loans, credit-card loans, loans guaranteed by the Small Business Administration, and certain other assets; (vii) [Paycheck Protection Program Liquidity Facility \(PPPLF\)](#) to provide liquidity to financial institutions that originate loans under the Small Business Administration's Paycheck Protection Program (PPP) which provides a direct incentive to small businesses to keep their workers on the payroll; (viii) [Main Street Lending Program](#) to purchase new or expanded loans to small and mid-sized businesses; and (ix) [Municipal Liquidity Facility](#) to purchases short term notes directly from state and eligible local governments.

• Supervisory action. Federal banking supervisors encouraged depository institutions to use their capital and liquidity buffers to lend, to work constructively with borrowers affected by COVID-19, and indicated COVID-19 related loan modifications would not be classified as troubled debt restructurings. Holdings of U.S. Treasury Securities and deposits at the Federal Reserve Banks could be temporarily excluded from the calculation of the supplementary leverage ratio for holding companies. Other actions include offering regulatory reporting relief and adjusting supervisory approach to temporarily reduce scope and frequency of examinations and give additional time to resolve non-critical, existing supervisory findings.

• Regulatory action. Lower the community bank leverage ratio to 8 percent. Provide extension transition for the Current Expected Credit Loss accounting standard. PPP covered loans will receive a zero percent risk weight, and assets acquired and subsequently pledged as collateral to the MMLF and PPPLF facilities will not lead to additional regulatory capital requirements. Allow early adoption of "the standardized approach for measuring counterparty credit risk". And there will be a gradual phase-in of restrictions on distributions when a firm's capital buffer declines.

• Fannie Mae and Freddie Mac have announced assistance to borrowers, including providing mortgage forbearance for 12 months and waiving related late fees, suspending reporting to credit bureaus of delinquency related to the forbearance, suspending foreclosure sales and evictions of borrowers for 60 days, and offering loan modification options.

Figure 9: Key policy responses to Civid-19 in the USA

- The economy converged with the US at the fastest pace on record. China's GDP was 71.4% of US levels in 2020, according to the International Monetary Fund, up 4.2% from the previous year
- The share of global trade increased as pandemic-related exports surged. Already the world's top exporter, China's shipments increased 3.6% in 2020, according to official data. Total world trade likely contracted 5.6%, according to estimates from the United Nations' trade and development body UNCTAD
- China likely regained the title as the world's top destination for foreign investment, which it lost to the US in 2015. Foreign investment into China reached more than \$129.5 billion through November 2020, slightly above the previous year. Globally, FDI flows are likely to have fallen 30 – 40% year-on-year in 2020, according to UNCTAD
- The Fortune Global 500 list of the world's largest companies by revenue for the first time contained more companies based in China, including Hong Kong, than the US: 124 vs. 121.
- Full-year movie box office receipts overtook the US for the first time.
- Sovereign debt was added to the FTSE Russel benchmark index, completing the country's inclusion in all three top global bond indexes. Foreign investors bought 1.1 trillion yuan (\$ 170 billion) of Chinese bonds in 2020.

Kishore Mahbubani is a Singaporean civil servant, a career diplomat and an academic. During his stint at the Ministry of Foreign Affairs from 1971 to 2004, he served as Singapore's Permanent Representative to the UN and held the position of President of the UN Security Council between January 2001 and May 2002. Between 2004 and 2017, he served as Dean of the Lee Kuan Yew School of Public Policy at National University of Singapore.

US Army General H.R. McMaster expressed the American attitude succinctly: "At the end of the day, the struggle between America and China represents the struggle between 'free and open societies and closed authoritarian systems.'" And just like the Soviets, the Japanese or the Nazis before them, this new "authoritarian" challenger, i.e. China, barely stands a chance against America, the de facto torchbearer of Western civilisation.

Except this time, as Mahbubani convincingly contends, the choice is not that straightforward. Burgeoning student debt, housing crisis, an ongoing opioid epidemic, a poor healthcare system, crumbling infrastructure - these are tell-tale signs of an empire in decline. Even more striking is the yawning gap between public policy and public opinion. Mahbubani cites several credible research papers which document the broad convergence of opinion among academics that policymaking in US is largely dominated by an increasingly small economic elite while the average American has little to no say. And while self-correction is baked into democratic institutions, they do not have the leeway to make major U-turns in a short timeframe.

Big issues: Uighur humanitarian crisis and the Xinjiang separatist movement, Tibet, Taiwan, Hong Kong, ...

Pollution, climate change, biodiversity loss The big challenge is to develop countries without crossing a sustainability threshold.

However...

- We showed, that regime shifts in society, economy, culture and technology are the natural phenomenon.
- In the past 150 years we have seen 2 shifts and 3 structural regimes.

We have seen that revolution, war, depression, genocide, nationalism during the First Shift led to a response of statesmanship, international cooperation and fairness (equity):

- Institutional reforms (e.g. Roosevelt's New Deal)
- International cooperation (e.g. Bretton Woods)
- A society contract between owners and workers so that the profits of progress are equitably shared

How could that happen now? And what could be possible pathways, plans, changes, solutions?

Project Tellus This is what we are trying to achieve with Project Tellus that is being set up at our chair in cooperation with Risk-X at SUSTech: "Achieving Human-Earth Sustainability". What is Tellus?

- Assemble a broad range of existing visions/insights of how Human-Earth Sustainability can be achieved through review of existing research and interviews of 'remarkable individuals' (the dragonfly eye view)
- Translate these into a systems dynamics model (the Human Earth Simulator), which will serve as a formal repository (of objects and interactions linked together in a dynamical system)
- Armed with the simulator, generate possible pathways and alternative futures that follow our mission, and that can be translated into actual and executable plans.
- Join forces with stakeholders from industry, policy makers and the general public - send out a 'Call for Action', build a community, focus on impact and solutions in industry and society.

One size does not fit all.

- Solutions must look the worldwide socioeconomic system and take for real the fact that 85% of the world's inhabitants are trying to catch up.
- Different regions, with varying economies, political systems and cultures need tailored solutions
- Carbon emission is only one dimension of humanity's ecological footprint. Solving this in isolation is likely to lead to unintended consequences. The Human-Earth system faces many more problems like biodiversity loss, pollution, health, inequality, stagnating economic growth, debt, water scarcity, erosion, waste,...

We follow these general Principles:

- Do not overemphasize the accumulation of knowledge and underemphasize the dissemination of what was learned - reach out!
- Focus on technical feasibility
- Submit any plans and solutions to rigorous simulations
- First do no harm ('Primum non nocere'), do not play the sorcer's apprentice
- Take a worldwide perspective and follow the fox' creed: 'one size does not fit all'
- Use common sense, prioritize and look foremost for big-impact solutions.

7 The macro status in China and the potential opportunity and risk for the World

1. China has woken up and become an integral part of the world
2. China is an old superpower with recent brief dent (How China fell and woke up)
3. China is a Confucius dominant country (East and West culture difference)
4. China is internally highly heterogeneous and complex

Why do we need to know about China?

- As an entrepreneur, you may want to know the largest market in the world and see how to make money from Chinese.
- As a global citizen, you may want to know how the world is becoming more polarized as the rising of China, which is one of the major hotspots of challenges and innovations.
- As a potential partner or competitor, you may want to know your team member or your enemy better.
- "If you know the enemy and know yourself, you need not fear the results of hundred battles. If you know yourself but not the enemy, for every victory gained you will also suffer a defeat. If you know neither the enemy nor yourself, you will succumb in every battle."

Status after Covid-19.

| US (and also Europe to some degree) | China |
|--|---|
| New budget and monetary experiment to stimulate final demand | Curb government spending and are constraining money supply growth |
| Launch massive investment programs at a time when there is little industrial spare capacity | Rein in government spending |
| Encourage a property and construction boom, even as the sector suffers shortage of workers and raw materials | Slow construction activity |

China's economic policymakers are using the space afforded them by a rapid economic recovery from the pandemic to refocus on a longer-term effort to redirect resources for strategic and political purposes.

Excess money. The idea is that over long term money supply should grow at roughly the same rate as nominal GDP. As a result, the ratio between the growth of excess money in two economies should indicate which way the exchange rate is heading - with the country showing the faster increase in excess money supply having the weaker currency.

Cyclical strength means short-term growth is not a worry Even after accounting for base effects, cyclical growth drivers boomed in 1Q21. Exports and property sales grew even faster than pre-Covid rates. Only consumption lagged, thanks to renewed public-health restrictions, but should recover quickly. The first quarter was probably the cyclical peak, and both reported and underlying growth will decelerate. Still, exports and property sales have been stronger than expected, so momentum is solid.

Favorable base effects and the strong cyclical bounce mean the government's deliberately low target of "above 6%" GDP growth in 2021 will be easily met; consensus forecast are for 8.5%. Provincial governments' growth targets are also quite conservative, as reduced urgency for growth has percolated down. The government began withdrawing emergency counter-cyclical support as early as mid-2020, and is continuing to do so in 2021.

Monetary and fiscal policy is tightening The turn in China's credit cycle is now well established, with total credit growth slowing to 12.3% YoY in March from the peak of 13.6% in October. The apparent sharp slowdown in March was due to base effects, not aggressive tightening; two-year growth shows a more moderate trajectory. But regulators are hawkish, and their reported plan to cap new loans this year implies total credit growth of ~ 11% for 2021, and possibly less.

The budgeted slowdown in total fiscal spending to just 4.9% in 2021 is a conservative signal to agencies and localities. Reduced fiscal support and the slowing credit cycle shows much less political urgency on supporting growth, and a higher priority on consolidating public finances. Since public sector investment was already weak in 2020, further weakness will not be a shock to growth. And incentives for new private investment are strong.

Environmental rules are tightening Another set of long-term priorities now getting a lot of short-term focus are those around energy and the environment. Top leader Xi Jinping has promised to cap China's carbon emissions by 2030 and achieve carbon neutrality by 2060. Many projections suggest the 2030 goal as achievable given recent rapid progress on renewable energy. But Xi's pledges have nonetheless led to a major shift in the policy environment.

Another trigger for tougher environmental enforcement was the 1Q21 resurgence in air pollution, particularly in north China (aggravated by a dramatic dust storm). The Covid collapse curbed heavy-industry emissions and the rebound is boosting them again. In previous air-quality campaigns the government has used forced reductions in steel output to produce pollution, and the steel sector is once again in policymakers' crosshairs.

Statistics to China and Switzerland See Lecture Slides pages 10-14.²

7.1 China has woke up and become and integral part of the world

ECONOMIC PREDICTIONS ABOUT CHINA:

1990. The Economist. China's economy has come to a **halt**.
1996. The Economist. China's economy will face a **hard landing**
1998. The Economist: China's economy entering a **dangerous period of sluggish growth**.
1999. Bank of Canada: Likelihood of a **hard landing** for the Chinese economy.
2000. Chicago Tribune: China currency move nails **hard landing** risk coffin.
2001. Wilbanks, Smith & Thomas: A **hard landing** in China.
2002. Westchester University: China **Anxiously Seeks a Soft Economic Landing**
2003. New York Times: **Banking crisis imperils China**
2004. The Economist: **The great fall of China?**
2005. Nouriel Roubini: The Risk of a **Hard Landing** in China
2006. International Economy: Can China Achieve a **Soft Landing**?
2007. TIME: Is China's Economy **Overheating**? Can China avoid a **hard landing**?
2008. Forbes: **Hard Landing In China?**
2009. Fortune: China's **hard landing**. China must find a way **to recover**.
2010: Nouriel Roubini: **Hard landing** coming in China.
2011: Business Insider: A Chinese **Hard Landing** May Be Closer Than You Think
2012: American Interest: Dismal Economic News from China: A **Hard Landing**
2013: Zero Hedge: A **Hard Landing** In China
2014. CNBC: A **hard landing** in China.
2015. Forbes: Congratulations, You Got Yourself A Chinese **Hard Landing**.
2016. The Economist: **Hard landing** looms for China
2017. National Interest: Is **China's Economy Going To Crash**?
2018. The Guardian: **A Chinese recession is inevitable**
2019. Forbes: The China «**Hard Landing**» is Back On The Table.
2020. The Washington Post: **China's Chernobyl? The coronavirus outbreak leads to a loaded metaphor**.

- GDP rose from 367.9 billion yuan in 1978 to 99.1 trillion yuan (\$14.4 trillion) in 2019.
- Since 2010, China surpassed Japan and has become the second-largest economy in the world, accounting for around 16 percent of world economy in 2019 (30% of world's economy growth), up 14 percentage points from 1978.
- In 2013, China's GDP in purchasing power parity (PPP) terms overtook the USA's in 2013, and now accounts for nearly 19% of global economy
- Per-capita GDP rose from 385 yuan (\$229) in 1978 to 70892 (\$10276) in 2019, lifting China from the notch of world's low-income to middle-income countries.

²<https://xyotta.com/cfiles/1205>

The government favors hardware over software Behind the hard line towards internet companies is a rethinking of which sectors really matter for national progress. China's government is now convinced that manufacturing matters more. Unlike the US, China does not see its internet companies as leaders of national innovation, but as sources of social problems. Internet entrepreneurs will get even more generous subsidies.

The current regulatory shift therefore is not negative for all Chinese listed companies, or even all technology companies. Policy support for strategically important sectors is ramping up, but most of those are hardware rather than software: most prominently, semiconductors and renewable energy. Hardware tech companies stock prices have done better than those of international platforms in recent weeks, which could be the start of a trend.

In 1981, three years after Deng's reform project was launched, almost 90% of Chinese people lived in extreme poverty by the definition of the World Bank (\$1.9 per day). By 2016, that number had dropped to less than 0.5%. By the end of 2020, it is 0.

2016 the world's largest radio telescope with a folded aperture in China was completed. The so-called FAST is a spherical radio telescope with a diameter of 500 meters. It began its work in Guizhou Province.

In 2006, the Qinghai-Tibet Railway began operations on the world's highest railway line, at an average elevation around 4500m above sea level. Tanggula railway station at 5068m is the world's highest railway station.

The third fastest supercomputer in the world as of Nov 2019. The Sunway TaihuLight was the world's fastest supercomputer for two years, from June 2016 to June 2018, according to the TOP500 lists. The record was surpassed in June 2018 by IBM's Summit.

- With progress on urbanization and industrialization, more jobs were created in urban areas, from 2.6 million new jobs in 2000 to 13.52 million in 2019.
- Total energy output rose from 627.7 million tons of standard coal in 1978 to 3.75 billion tons of standard coal in 2017.
- From 1978 to 2017, China's state revenue increased from 113.2 billion to 17 trillion yuan.
- China's retail sales of consumer goods grew from 155.9 billion yuan in 1978 to 41.16 trillion yuan in 2019.
- China's foreign trade volume rose from \$20.6 billion in 1978 to \$4.1 trillion in 2017. About 58.52% of people lived in towns and cities in 2017, compared to 17.92% back in 1978.
- China's high-speed railway developed from nothing. Up to 2017, the high-speed railway network covered 25000 km.
- Auto industry has witnessed an uptrend in production over the past 40 years. The volume hit 29.02 million in 2017, up from 149000 back in 1978.

China has been one of the major driving forces in the world.

Chinese visitors account for a rising share of visitor and tourist spending in many economies.

China is the world's manufacturing superpower.

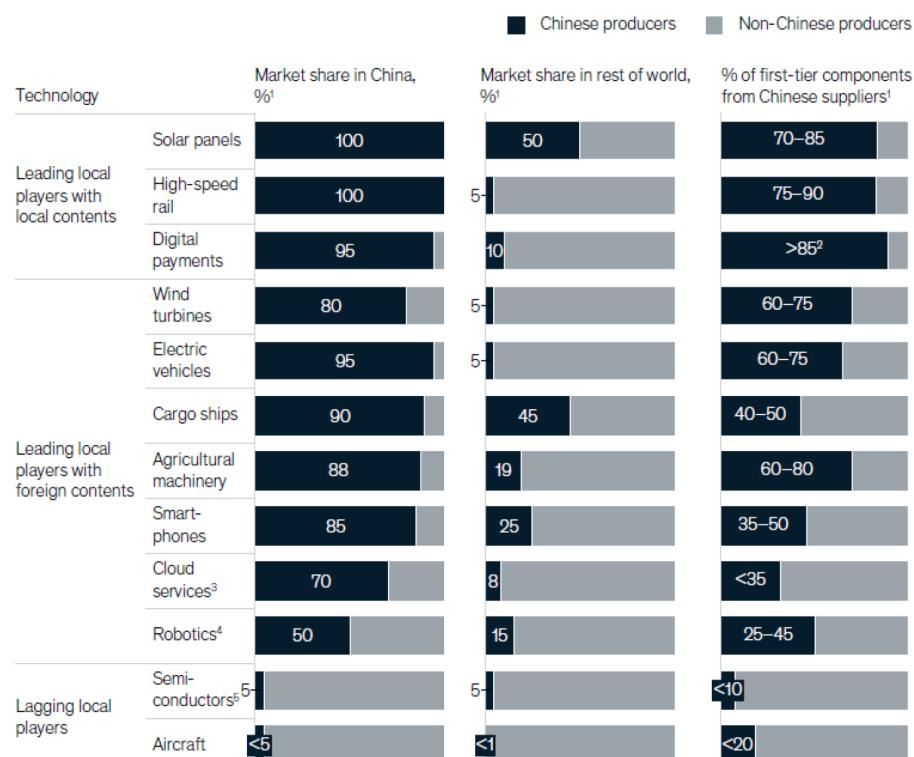
- China accounts for 30% of global manufacturing output.
- Although it accounts for only 10% of global household consumption, it was the source of 31% of global household consumption growth from 2010 to 2017.
- In many categories including automobiles, spirits, luxury goods, and mobile phones, China is the largest market in the world, accounting for about 30% of global consumption.
- The world's second-largest source and second-largest recipient of FDI between 2015 and 2017.

7 THE MACRO STATUS IN CHINA AND THE POTENTIAL OPPORTUNITY AND RISK FOR THE WORLD

7.1 China has woke up and become and integral part of the world

China is so interconnected with other nations in trade that blocking china as a trade partner would also cause effects for third countries.

| Archetype | Sector name | Trade intensity | Chinese share of global exports, % | | Chinese share of global imports, % | |
|---|--|-----------------|------------------------------------|---------|------------------------------------|---------|
| | | | 2003–07 | 2013–17 | 2003–07 | 2013–17 |
| High level of integration | Computer, electronic, and optical products | | 15 | 28 | 12 | 16 |
| | Electrical equipment | | 16 | 27 | 7 | 9 |
| | Other machinery and equipment | | 7 | 17 | 8 | 9 |
| High exposure to Chinese exports | Textiles, apparel, and leather | | 26 | 40 | 5 | 5 |
| | Furniture, safety, fire, other | | 17 | 26 | 2 | 4 |
| | Other nonmetallic mineral products | | 11 | 22 | 5 | 8 |
| | Rubber and plastics | | 10 | 19 | 5 | 7 |
| | Basic metals | | 8 | 13 | 8 | 8 |
| High exposure to Chinese imports | Mining and quarrying | | 1 | 1 | 7 | 21 |
| | Chemicals | | 4 | 9 | 9 | 12 |
| | Paper and paper products | | 3 | 9 | 6 | 12 |
| Global chains with little trade exposure to China | Other transport equipment | | 3 | 6 | 3 | 5 |
| | Pharmaceuticals | | 2 | 4 | 1 | 3 |
| | Motor vehicles and trailers | | 1 | 3 | 2 | 7 |
| | Coke and refined petroleum products | | 2 | 4 | 4 | 6 |
| Local production for local consumption | Food, beverages, and tobacco | | 3 | 4 | 3 | 6 |
| | Fabricated metal products | | 14 | 23 | 3 | 5 |
| | Wood and wood products | | 11 | 22 | 2 | 3 |
| | Printing and media | | 8 | 18 | 2 | 4 |
| | Agriculture, forestry, and fishing | | 5 | 5 | 7 | 19 |

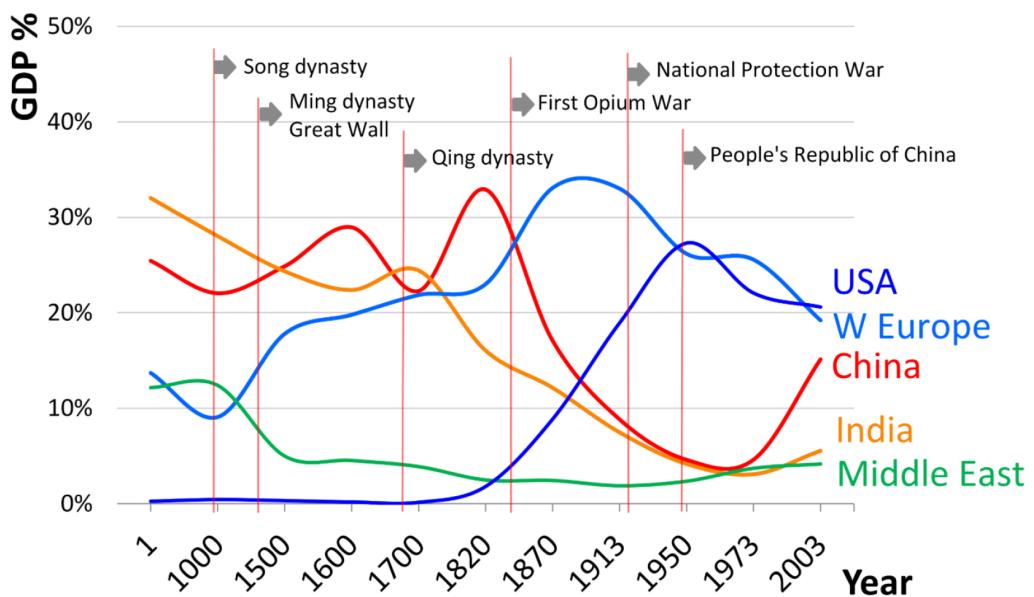


| Growth factors | How they worked | Features and implications |
|--------------------------------------|---|--|
| Capital accumulation | Low dependency ratio conducive to high savings; unlimited supply of labour prevents diminishing return on capital | Unsustainable; as labour becomes scarce, return on capital begins diminishing |
| Quantity of labour | Population structure guarantees labour supply, which turns into comparative advantage in labour-intensive manufacturing | Unsustainable; demographic dividend disappears as economy passes Lewis turning point |
| Human capital | Education expansion and mass labour entry improves quality of stock of workers | Education expansion eventually slows, calling for enhancing its quality and equality |
| TFP | Increase from improvement of incentives and resource allocation system | Increasingly challenging and important to sustain growth; requires new sources of increase |
| TFP, of which: resource reallocation | Reallocative efficiency of resources through labour mobility from agriculture to industrial sectors | Dominant in early stage of development; diminishes after Lewis turning point |
| TFP, of which: technology | Utilisation of advantage of backwardness through absorbing foreign technology and management | As gap narrows, technological progress increasingly relies on independent innovation |
| Population factor | Widely defined demographic dividend is manifested in all factors driving rapid growth | Diminishes as China ages; second dividend available from removing remaining barriers to movement |

Figure 10: Summary Chinese Trade

7.2 China is an old superpower with a recent brief dent (How China fell and woke up)

History of China: Ancient China and Century of Humiliation (1839-1949). People's Republic of China: 1949-1978 and 1979-now.



The European explorer Marco Polo (1254-1324 CE) traveled on the trading routes centered on the Silk Road and described them in depth in his famous work but he is not credited with naming them. Both terms for this network of roads were coined by the German geographer and traveler, Ferdinand von Richthofen, in 1877 CE, who designated them 'Seidenstrasse' (silk road) or 'Seidenstrassen' (silk routes). Polo, and later von Richthofen, make mention of the goods which were transported back and forth on the Silk Road.

Four great inventions

Paper Making In the early Western Han Dynasty, China invented papermaking. Papermaking is a great revolution in writing materials.

Printing In the early Tang Dynasty, engraving printing was invented from the seals and engraving stone.

Movable type printing In the early 11th century, Bi Sheng, a civilian in the Northern Song Dynasty, invented movable type printing, which was more than four centuries earlier than the European invention. The spread of North Korea and Japan to Egypt and Europe to the west. The invention of printing is a major contribution to the spread and preservation of human culture.

Gunpowder It was invented by ancient alchemists in China, and the books in the middle of Tang recorded the method of making gunpowder. It was used in the military in the late Tang Dynasty. It was invented in the Southern Song Dynasty, and was introduced into Arabia and Europe in the 13th century. The invention and spread of gunpowder changed the medieval mode of warfare and was a major event in the military era.

Compass During the Warring States period, people made the instrument "Sinan" indicating the direction, and later using the principle of magnet guide to make a compass. In the Song Dynasty, the magnetized steel needle support was fixed in an azimuth-engraved disk for pointing. This is the compas, also known as the compas needle. The compass of the Northern Song Dynasty was used for navigation. Introduced to Arabia and Europe in the 13th century. The invention and spread of the 13th century. The invention and spread of the compass provided important conditions for european navigators to explore new routes.

7.2.1 Century of Humiliation (1839-1949)

In this period, China suffered major international fragmentation, lost almost all of the wars it fought, and was often forced to give major concessions to the great powers in the subsequent treaties. In many cases, China was forced to pay large amounts of reparations, open up ports for trade, lease or cede territories and make various other concessions of sovereignty to foreign "spheres of influence", following military defeats.

- Defeat in the First Opium War (1839-1842) by the UK.
 - Treaty of Nanking (Aug 1942): cession of Hong Kong; four additional "treaty ports" opened for foreign trade; 21 million dollars reparations (annual income 57 mio)
- The Taiping Rebellion (1850-1864): One of the bloodiest wars in human history, the bloodiest civil war, and the largest conflict of the 19th century. Estimates of the war dead range from 10-30 million.
- Defeat in the Second Opium War (1856-1860) and the sacking of the Old Summer Palace by British and French forces.
- The Sino-French War (1884-1885)
- Defeat in the First Sino-Japanese War (1894-1895) by Japan
 - Treaty of Shimonoseki (Apr 1895): recognized the independence of Korea and renounced any claims to that country; ceded the Liaodong Peninsula, and the islands of Formosa (Taiwan) and Penghu (also known as Pescadores) to Japan; paid Japan a war indemnity of 200 million Kuping taels silver (7500 tons), payable over seven years; opening of various ports and rivers to Japanese trade.
- The Eight-Nation Alliance (Austria-Hungary, France, Germany, Italy, Japan, Russia, the US and the UK) suppressing the Boxer uprising (1899-1901)
 - Boxer Protocol (Sep 1901): 450 million taels of fine silver were to be paid as indemnity over 39 years to the eight nations involved; to prohibit the importation of arms and ammunition; the destruction of Taku Forts; Legatin Quarters occupied by the Powers shall be considered as a special area reserved for their use under exclusive control, in which Chinese shall not have the right to reside, and which may be defensible; concede the right to the Powers to station troops in 12 cities/places; Boxer and Governments or their nationals.

- British expedition to Tibet (1903-1904)
- The Twenty-One Demands (1915) by Japan
- Japanese invasion of Manchuria (1931-1932)
- The Second Sino-Japanese War (1937-1945): 15-22 million death

The Mao Era (1949-1977): Mao Zedong's tenure as Chairman of the PRC triggered sweeping changes for the country.

- 1953-1957: First 5-Year Plan: The program's aim was to boost China's industrialization. Steel production grew four-fold in four years, from 1.3 million tonnes to 5.2 million tonnes. Agriculture output also rose, but it couldn't keep pace with industrial production.
- 1958-1962: Great Leap Forward: The campaign emphasized China's agrarian-to-industrial transformation, via a communal farming system. However, the plan failed - causing an economic breakdown and the deaths of tens of millions in the great Chinese Famine.
- 1959-1962: Lushan Conference and 7000 Cadres meeting: Top leaders in the Chinese Communists Party (CCP) met to create detailed policy frameworks for the PRC's future.
- 1966-1976: Great Proletarian Cultural Revolution: Mao Zedong attempted to regain power and support after the failures of the Great Leap forward. However, this was another plan that backfired, causing more deaths by violence and again crippling the Chinese economy.
- 1971: Joined the UN: The PRC replaced the ROC (Taiwan) as a permanent member of the UN. This addition also made it one of only five members of the UN Security Council - including the UK, the U.S., France, and Russia.
- 1972: President Nixon's visit: After 25 years of radio silence, Richard Nixon was the first sitting US President to step foot into the PRC. This helped re-establish diplomatic relations between the two nations.
- 1976-1977: Mao Zedong Death, and "Two Whatevers": After Mao Zedong's passing, the interim government promised to "resolutely uphold whatever policy decisions Chairman Mao made, and unswervingly follow whatever instructions Chairman Mao gave."
- 1979: "One-Child Policy": The government enacted an aggressive birth-planning program to control the size of country's population, which it viewed as growing too fast.
- When the PRC (People's Republic of China) was established in 1949, China accounted for 4.2% of the global economy, but this number increased to only 4.9% by 1978. In 1949, GDP per capita was \$23, and was \$156.4 in 1968.

Before 1978 the leaders were more ideologicistic. After, no matter which regime, as long as it works.

Reform and development strategy Justin Yifu Lin and Zhongkai Shen (2018). In China's 40 Years of Reform and Development 1978-2018.

- Why was China able to achieve such extraordinary growth during its transition? Why was China able to grow so dynamically during the reform period? Answer: The latecomer advantage.
- Why was China unable to attain similar success before its transition started? If the latecomer advantage was the reason for China's extraordinary growth performance after 1978, the same advantage should have existed for centuries before 1978, so why did China not benefit before the reform and opening-up? Answer: Because China voluntarily gave up the latecomer advantage.
- Why did few other transitional economies perform equally well? Answer: Because other economies followed the wrong transition strategy: the neoliberal 'Washington consensus', which was based on the argument that the misallocation of resources caused by excessive government intervention led to unsatisfactory economic performance. 'shock therapy'. China adopted a pragmatic, gradual and dual-track approach.

7.3 China is a Confucian dominant country (East and West culture difference)

- Shower: West: Morning, East: evening
- Waiting Queue: West: line, East: bunch of people
- Way of life: West: independence and individualism, East: community oriented
- Restaurant: West: calm, East: noisy
- Punctuality: West accurate, East: flexible
- Opinions: West: straight forward, East: complicated
- Making Contacts: West: linear relationships with few people, East: circular relationships across many people
- Anger/Displeasure: West: If unhappy, emotions can be perceived through body language etc, East: Norm is to hide displeasure
- View of Myself: West: most important, East: part of the sum.
- Handling Problems: West: most direct approach, East: involve indirect approach
- The Boss: West: weaker influence, East, great authority and influence as well as respect.
- Truth: West: honest, East: liar
- Talking about Money: West: no problem, East: not appropriate to talk about money

7.3.1 Confucianism

The main foundations of Confucianism emphasize duty, sincerity, loyalty, honor, filial piety, respect for age and seniority. As individuals maintain harmonious relations among themselves, society itself becomes stable.

- Balance
- Harmony
- Modest
- Hierarchy
- Seniority
- Internal Harmony

Chinese business culture is largely influenced by Confucianism. The Confucian concept of Guanxi means that a relationship network is crucial and based on the values of solidarity, loyalty, modesty and courtesy. Hierarchy in China, both in business and privacy, is purely vertical and highly respected. Chinese people will be careful to save face in order to protect individual reputations, influence and dignity. Some of these values have slowed down over the last decade and modern Western business approaches are gaining ground.

Collectivism vs. Individualism This is referred to as the degree to which individuals in a certain country prefer acting as individuals rather than as members of groups. This dimension focuses on the relationship between the individual and the larger social groups.

It encourages people to pull up their socks and get out of poverty. On the other hand, China as collectivistic society encourages more group work and puts more emphasis on strong relationship between individuals hence the basis of guanxi. To them, the needs of a group are way more important than individual needs.

Characteristics of Individualistic Cultures

- Fosters contractual relationships that revolve around the basics of exchange. In such cultures, calculation of the profit or loss of engaging in a particular behaviour is calculated before going for it.
- Concentrates more on self and the very dear or near ones as well as concern with behavioural relationships as well as own interests, needs and own goals.
- More emphasis on personal pleasure, over duties, fun, enjoyment and social norms. They are part of in-groups, but they hardly have any influence on their lives.
- Value independence and self-sufficiency with self-interest placement rather than collective interests. In such societies, confrontation is an acceptable attribute.
- They hold unique beliefs and decisions are made based on individual needs.

Characteristics of Collectivistic Cultures

- For maintenance of social harmony among in-group members, the behaviour must subscribe to the social norms established.
- More giving up of personal interests and sharing of resources to facilitate the collective interests.
- Before making any major decision must consider the implications to the wider collective.
- Favoritism especially to in-groups including family and friends.
- Be a part of few influential in-groups and inclining towards conformality.
- Increased concern when it comes to ingroup members but show indifference or hostility towards out-group members.
- Much emphasis on hierarchy and harmony within the group.
- There are group norms which help in the regulation of behaviour.

FACE

- One of the central concepts in Chinese social life is 'face' (mianzi) because China is a collectivistic society in which social harmony is of utmost importance.
- Face reflects one's social self-esteem and the way one is regarded in society and interpersonal interactions.
- People can 'have face' as long as they are respected by others, but they can 'lose face' when they experience a public embarrassment.
- Public disagreement is a face-losing act of the Chinese: they prefer articulating the intentions in an indirect manner and leaving room for negotiations in private. Enhancing or saving others' face helps tremendously in building friendships and creating interpersonal goodwill.
- Face-saving actions sometimes are the cost of precision, accuracy, and clarity and may become compatible with honest or truthful communication practices.

Communication

- To Westerners, the word 'yes' suggests agreement and affirmation, but to Chinese a 'yes' may only convey the meaning of 'I am listening' with the purpose of showing attention and politeness.
- Chinese way of communication focuses on different elements, including implicit, context-based, listening-centered, and face-oriented methods.
- Unlike the Western communication pattern, Chinese prefer to use an implicit language pattern - meaning is often implied and must be inferred.
- Also, they tend to take context and the specific situation into account when interpreting a word. So the ability to surmise and decipher hidden meanings is highly desirable in Chinese culture.

Modesty

- Chinese people value modesty and humbleness.
- To grow up as a Chinese, one learns not to take credit for one's behaviour or be boastful in any situation.
- Self-effacing/other-enhancing is common rule in Chinese socialization process.
- When receiving a compliment such as 'your son is an excellent boy', a Chinese would automatically say 'not really'.
- In Chinese culture, blatantly accepting a compliment is considered impolite.
- However, young Chinese professionals do not tend to keep a low profile. They tend to be more confident, self-expressive and direct.

7.4 China in internally highly heterogenous and complex

China often seems like a nonolith of 1.3 billion people, but it's not. It's a mosaic of distinct regions, and understanding those regions is vital to understanding China.

The Chinese are people with diverse physical traits, dialects and traditions. They are multicultural, multireligious, and a multiethnic society, having as many as 55 ethnic groups as diverse and interesting as the geography and the history of the country they inhabit. Several of them are descendant of Arabs who came here via the Silk Road in early centuries.

- Language: 8 main variants of spoken Chinese and hundreds of less common ones
- 56 Ethnicity
- Regional Stereotypes
- Economic development

The Nine Nations of China

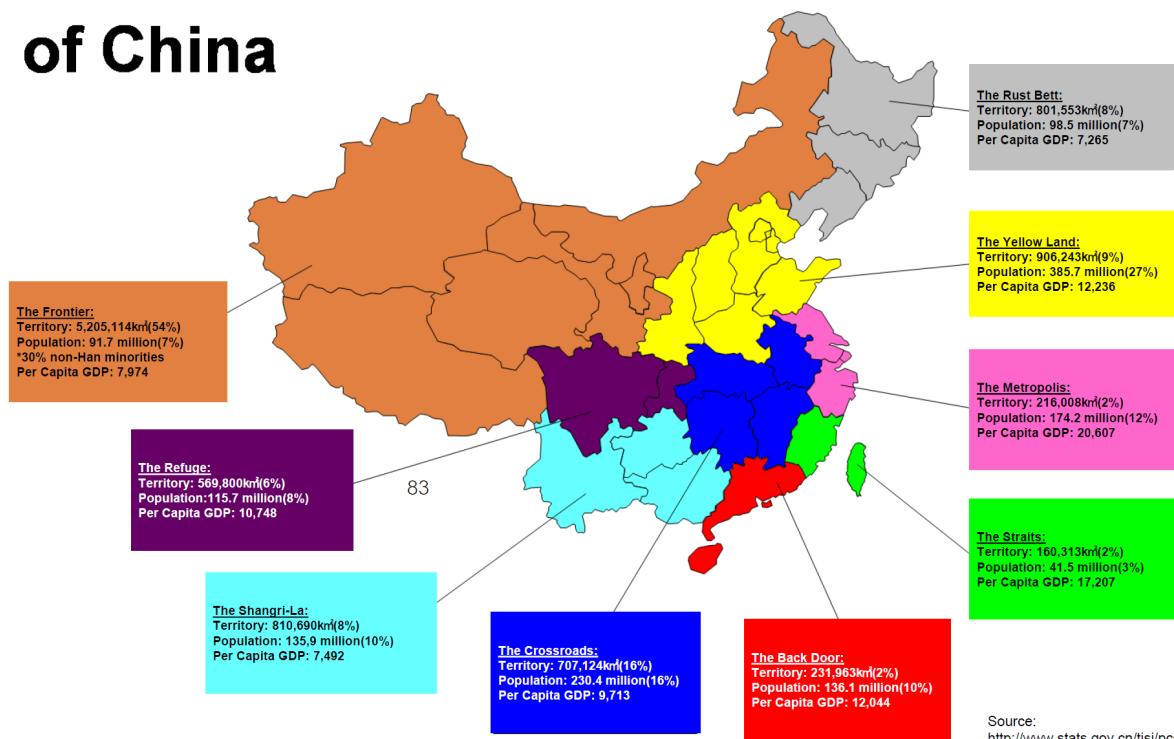
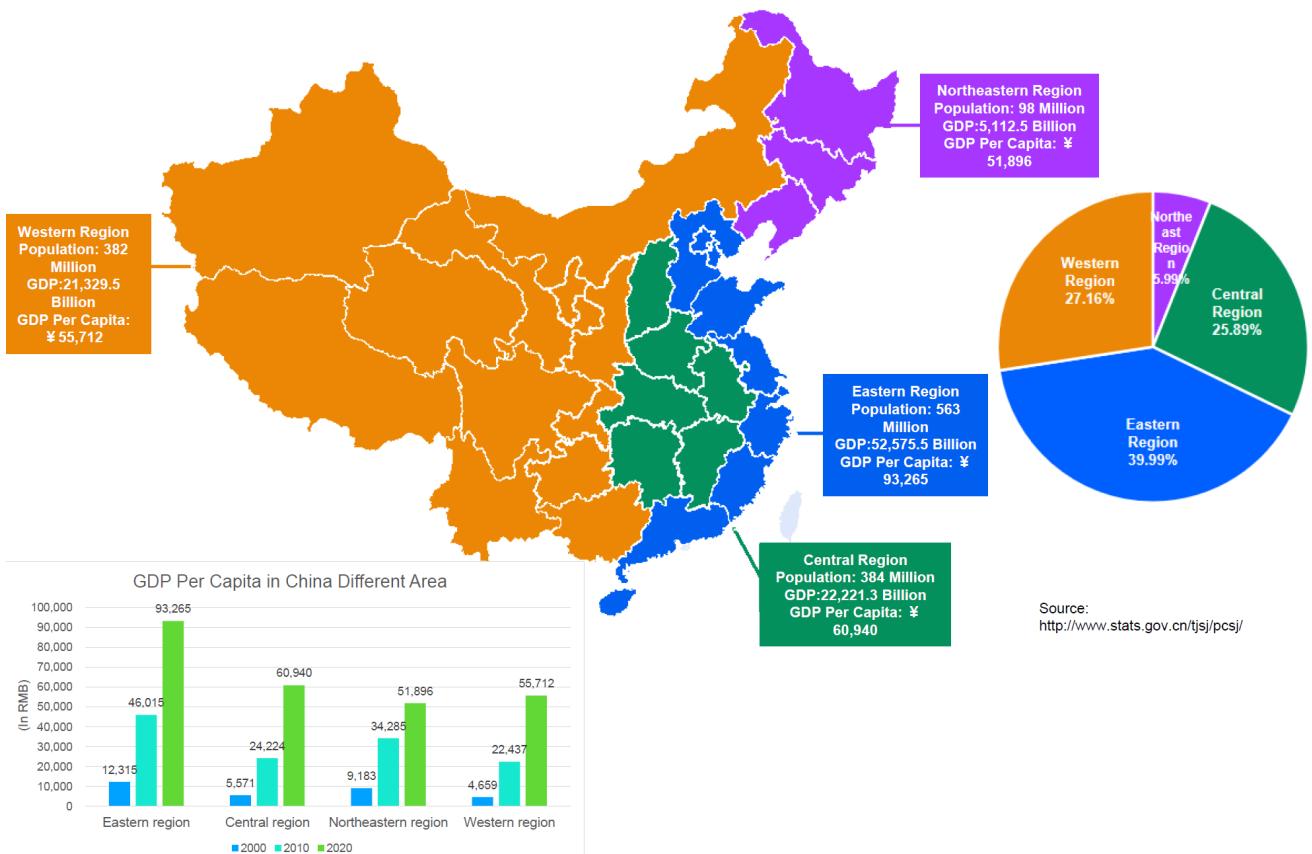


Figure 11: The nine nations of China



There is a strong correlation between political freedom and economic success of a country. Human societies must create stable sources of food energy, or they die out. The ability to access reliable sources of food energy is a function of the available technology for growing, storing, and transporting food crops. Given any particular state of technology, brute facts of nature determine the amount of accessible food energy by affecting what can be grown, how much of it can be grown, whether it can be stored, and the distance at which it can be traded.

4 Complex Adaptive Systems

- Transactional Complex Adaptive Systems
 - Produce, relatively large fertile land, idiosyncratic weather shocks
 - Shock \Rightarrow move and trade \Rightarrow rule of law and democratic system
- Insurance Complex Adaptive Systems
 - Produce, relatively large fertile land, aggregate weather shocks (massive shock lasting for years)
 - Centralized coordination system
- Subsistence Complex Adaptive Systems
 - Produce but not be able to store (tropics with rainfall)
 - No trade \Rightarrow no surplus \Rightarrow no investment in human capital and other infrastructural systems \Rightarrow bands/tribes
- Pastoral Complex Adaptive Systems
 - Not possible to produce enough kilocalories \Rightarrow expand, move to outrun aggregate weather shocks (Steppe ecosystems)

8 The collision of the two opposite mindsets: Innovation and Entrepreneurship in China and Switzerland

8.1 Switzerland is an old friend of China

Switzerland had significant economic interests in China at the time, especially in Shanghai. The prompt recognition of the new communist government, as well as Switzerland's status as a neutral country, allowed it to gain political advantage and carve out a role as mediator in the region.

On October 7, 1949, the Federal Council (Swiss executive branch) had already decided to recognise the Chinese government, in order to avoid being "either one of the first or the last" to do so.

The official recognition came on January 17, 1950. Of the Western nations, only Great Britain and Scandinavian countries were earlier in doing so.

The two countries formally established diplomatic relations on September 14 in the same year.

In the 1970s, the good Swiss-Chinese relations revolved mainly around the hope that the Swiss economy might benefit from the future opening of the Chinese market to external commerce. And indeed, in December 1974, Bern and Beijing signed a trade deal - and then a free trade agreement 40 years later.

Bilateral relationship in recent years



- Switzerland has also strengthened financial ties with China over the years. In December 2018, UBS became the first foreign bank to gain majority control of a financial institution on mainland China by increasing its stake in the UBS Security joint venture to 51%.
- In 2016, the China Construction Bank (CCB) became the first Chinese bank to open a branch on Swiss soil. CCB was followed by the Industrial and Commercial Bank of China a year later. The development has cemented Switzerland's position as a renminbi trading hub.
- A latent trade war currently exists between China and several Western countries, notably the US. Not with Switzerland though. Sino-Swiss economic ties were deepened by a free-trade agreement external link (FTA) that came into force on July 1, 2014. This is one of the few FTAs that China has signed external link with countries outside the Asia-Pacific region.
- Billed to save Swiss companies CHF 290 million annually by the time all trade barriers are lifted in 2023, a study last year found the FTA had achieved savings of CHF 100 million for both Swiss and Chinese firms in 2017.

- More than 80 Swiss companies are now in Chinese hands, with a total value of CHF 46 billion. The \$43.3-billion takeover of agrochemical giant Syngenta by the China National Chemical Corporation (ChemChina) in 2016 is the biggest acquisition ever by a Chinese company.

Import and Export:

- Export elasticity can be used to determine the effects of a sharp decline in China's growth on Swiss exports. Under the assumption of a constant exchange rate, export elasticity shows by how many percentage points the exchange growth in Switzerland would increase or decrease if the growth of China's GDP changes by one percentage point.
- The elasticity between Switzerland and China is not statistically significant. However, when you look at individual industries, you see that, at 2.6 percent points, the food industry in particular is very dependent on China's economic situation. The watch and machinery industries are also especially sensitive to changes in the Chinese economy.
- Switzerland exports mainly finished products, so the Swiss economy is particularly dependent on Chinese final demand.
- Swiss exports to Germany are also influenced by China's economic development, as 20% of exports to Germany are processed there and then exported to China, among other countries. One prominent example of this is the automotive industry.

Primary Chinese Motivations for the Sino-Swiss FTA

| 1 General | 2 General | 3 General | 4 Swiss-specific | 5 Swiss-specific |
|--|--|---|---|---|
| Trust Mutual trust and understanding, based on diplomatic and political perspectives. Note: CH supported CN's market economy status, and is seen as having aligned political interests. (Kong 2012, Zeng 2016) | Complementarity Mutual gains. Note: CN does not take industry perspectives (although feasibility studies identify sectorial beneficiaries). The FTA decision is centrally made –a macro, whole picture prevails. This contrasts with Western countries where negotiation groups drive/ block FTAs. (Kong 2012) | Commitment (of counterpart) CN assess motivation and commitment of potential FTA Partner. Note: CH seen as very open and liberal, willing to sign, and easier to negotiate with than other advanced countries. (Kong 2012, Li 2014) | Learning China gains negotiation experience with advanced/ European countries. Note: The SS-FTA was one of the most comprehensive CN FTAs, a template for negotiations with advanced countries. (Zhang, 2013) | Signal to Europe China sends strong signals of further opening up and cooperation to Europe Note: Switzerland is seen as gateway to Europe, to ready CN for the EU market and for possible future EU FTA negotiations. (Wu et al. 2013, Lanteigne 2014, Xinhua News 2013) |

Primary Swiss Motivations for Sino-Swiss FTA

| 1 General | 2 General | 3 China-specific | 4 China-specific | 5 China-specific |
|---|--|--|--|---|
| Exports Increased CH market access. Note: "To provide Swiss companies with an unobstructed, stable and non-discriminatory market access (...)." (SECO 2018) | Global Competitiveness All trade, incl. CN imports, is economically beneficial for CH. Note: Swiss policy of "(S) strengthening Switzerland's competitiveness as a business location; FTAs enable Switzerland to secure its place within the global value added chains". (SECO 2018) | Importance After the US and the EU, CN is CH's third largest trading partner. (SECO 2018) | Complementarity "True Win-Win situation" (SECO 2010, FDFA 2018) | Chinese Market Competitiveness Non-export-related CN market positioning: Note: "(C)ompetitive advantage compared to other countries which do not have a FTA with China and prevents discrimination against Swiss economic operators compared to China's existing and future free trade partners." (FDFA 2018) |

Why China needs Switzerland

- An entry point to European market
- A signal to Europe and the west advanced economies
- An entry point to the global stage via international organizations
- A neutral and friendly country
- A balance with Europe and the US

Why Switzerland needs China

- A huge and competitive market
- Engagement in an emerging power in the global stage
- A balance with Europe and the US
- A "client" that Switzerland has been selling its neutrality service to

Chinese Strategy: three principle for cooperation China has been investing heavily in education, research and innovation for years and shares a great deal of knowledge in fields including finance, science, culture and environment protection. It is these areas especially that Switzerland wishes to cooperate with the PRC, which is listed as a priority country in Switzerland's Foreign Policy Strategy 2020-23. Three fundamental principles underpin Switzerland's cooperation with China. These apply to bilateral relations, multilateral cooperation and coordination in Switzerland.

- Switzerland wishes to pursue an independent policy on China and defend its long-term interests and fundamental values. It will seek to do this through constructively critical dialogue with Chinese representatives in the diverse areas of Swiss-China relations where there is an opportunity to engage on the issues.
- The Federal Council advocates the integration of China in the liberal international order and will seek to coordinate more closely with like-minded partners.
- Finally, it pursues a balanced, coherent and coordinated approach to China that encourages exchanges with Parliament, the cantons, academia, the private sector and civil society

"Pioneering spirit and pragmatism, in addition to a strong stance in the defence of Swiss interests and values, have moulded Switzerland's policy on China for seventy years. They will continue to do so." - Ignazio Cassis

8.2 Competence of the two nations

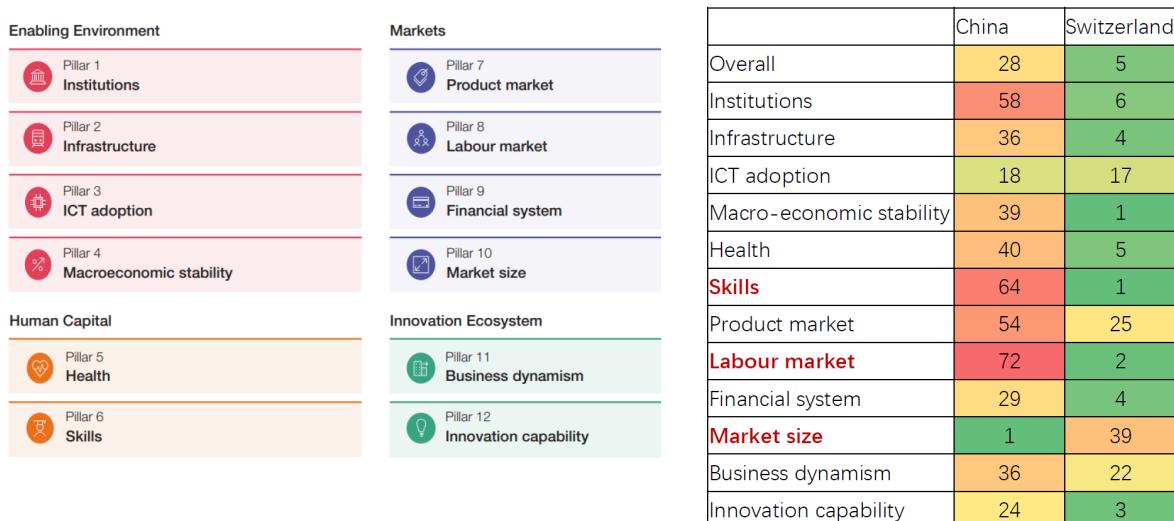
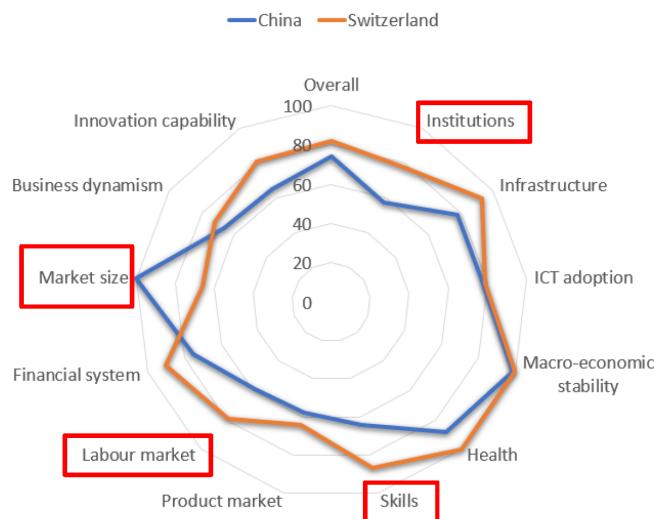


Figure 12: Global Competitiveness Index



Switzerland has been innovation leader for the last 10 years.

Strengths

- GII strengths of China are found in six of the seven GII pillars, and mostly on the innovation output side of the GII, which captures countries' innovation results.
- Several of these strengths are in knowledge and technology outputs, the best ranked GII pillar for China. Here the country's strengths are sub-pillar knowledge creation and knowledge impact and indicators Patents by origin, Utility models by origin, Labor productivity growth, and Hightech exports. In all of these indicators, China is world leader this year.
- In Creative outputs, China's strengths are sub-pillar Intangible assets and indicators Trademarks by origin, Industrial designs by origin, and Creative goods exports. In all of these areas, China ranks first in the world.
- On the innovation input side, China's strengths are found in four areas:
 - In Human capital and research, an important GII strength is indicator Quality of universities, where China is placed 3rd worldwide, after the US and the UK.
 - In Business sophistication, China's strength are indicators Firms offering formal training, R&D financed by business, and Hightech imports.
 - In Market sophistication, relative strengths are sub-pillar Trade, competition and market scale and indicator Domestic market scale, where China positions 1st globally.
 - In Infrastructure, China's strength is indicator Gross capital formation.

Weaknesses

- China's weaknesses in the GII are found in all GII pillars, except for knowledge and technology outputs.
- Most of these weaknesses are found on the innovation input side of the GII, which captures the investment that economies make to produce more and better innovations.
- In Institutions, China's weaknesses are sub-pillar Regulatory environment and its indicator Cost of redundancy dismissal.
- In Human capital and research, relative weaknesses are sup-pillar Tertiary education and indicator Tertiary inbound mobility.
- In Infrastructure, China presents relative weaknesses in two indicators within the area Ecological sustainability - GDP per unit of energy use and environmental performance.
- Indicator Microfinance gross loans in a relative GII weakness in Market sophistication.

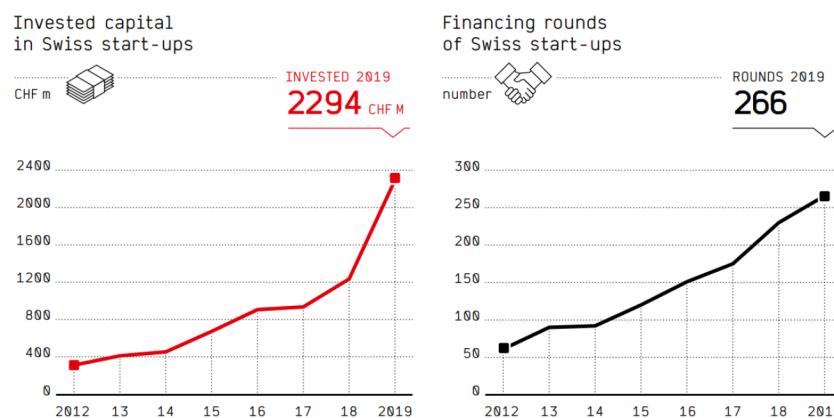
- In Business sophistication, indicators R&D financed by abroad and FDI inflows are GII weaknesses for China.
- Three relative weaknesses are found in Creative outputs in indicators National feature films, Printing and other media, and Wikipedia edits.

8.3 Swiss startups and innovation

471 ETH spin-offs since 1996 (93% 5-Year survival ratio), 41 acquired or went IPO.

The ETH Domain under the Swiss Confederation, which includes 2 federal universities and 4 federal institutions, forms the backbone of Swiss scientific and technological innovation, incubating 60-100 Hightech companies each year, with ETH Zürich being the largest institution in the domain.

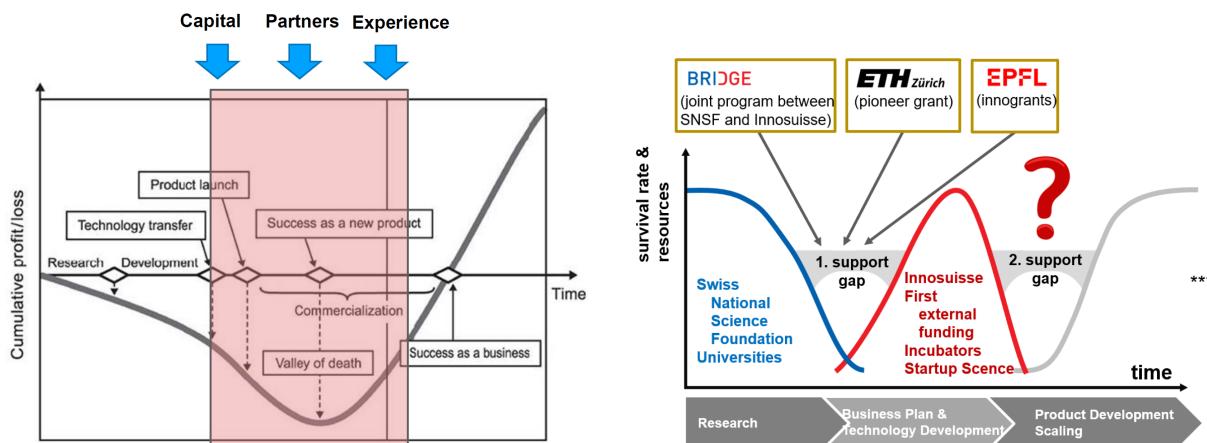
| | Swiss Start-ups | Other Start-ups |
|-----------------------|-----------------------|-----------------|
| Innovation model | Show Me | Believe Me |
| Entrepreneur culture | Conservative, prudent | Aggressive |
| Impact | Relatively lower | Higher |
| Industries | High-tech mainly | Comprehensive |
| Risk preference | Low | High |
| Average return | High | Low |
| Enterprise life | Long | Short |
| 5-year survival ratio | 50% (ETH 92%) | <10% |



Life sciences industry (including biotechnology, medical devices, health information technology, eth.) as a traditional advantage industry remains stable. The information and communications technology industry has risen rapidly in recent years, with a significant growth rate, and the amount of venture capital investment doubled in 2019.

From 2012 to 2018, the average amount of Swiss startup financing increased by 26% per year, reaching nearly 8.7 billion yuan in 2018, equivalent to four times the amount of venture capital in 2012, and an average of 42 million yuan per financing transaction.

Most Projects are very easy to get seed round funding and funds after the A round, but the intermediate funding (between 2 million and 10 million Swiss francs) is very difficult to obtain, which provides an excellent opportunity for Chinese capital to cut in.



8.4 Chinese startups and innovation

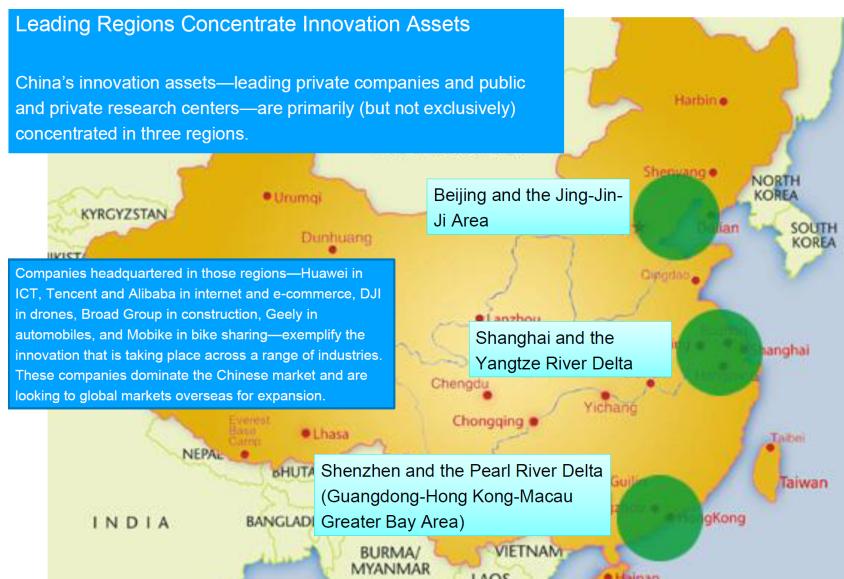
China's spending on research and development in science and technology, surged ten-fold since 2000, while the US spending grew a modest 39% in the same period.

The Chinese intellectual property protections grew over time just as in the US just with a time shift of approximately 100-200 years.

Innovation refers to the ability to produce new economic value through the creation or improvement of products or business services. It can take many forms. At one end of the spectrum is transformational innovation - something that fundamentally alters a market or an industry. Often, but not always, it is based on scientific research. But innovation can also be incremental - a modification or enhancement to an existing product or service that improves its market position and increases its economic value.

China has advanced far beyond the mere copying of Western products or technologies and now excels at incremental innovation. It still lags the US, Europe, and Japan in transformational, science-based innovation, but with a sustained policy focus and investment by its government and the leverage provided by a massive domestic market, transformational innovation can also be expected to advance.

Advances are clear at the national level, in fields such as supercomputing, quantum communications, space, and robotics. In the private sector, advances can best be seen in mobile commerce, where China currently leads the world. While the innovations driving China's commercial success are mostly incremental, they are increasingly enabled by investment in artificial intelligence (AI). Outside of mobile commerce - in fields such as semiconductors, software, commercial aircraft, and life sciences - China's advance is more uneven. Even in those sectors, however, sustained investment is likely to bring change.



China also has an increasingly robust startup scene, with a rapidly growing number of incubators and accelerators. Many are sponsored by provincial and city governments, offering benefits such as grants or free rent. It is not clear, however, whether their rapid expansion reflects a similar scale of innovation, or whether it constitutes a bubble.

There is also growing private investment in startups, by large companies such as Tencent, Alibaba, and Baidu, and through an array of venture capital and private equity firms. Reflecting the scale of this activity, in 2016 China led Asia in the production of unicorns (companies with valuations of \$1 billion or more) with 37; the country with the next largest number was India with 8. Internet companies are receiving more than half of China's venture deal flow, and of China's 46 unicorns in 2017, nearly half are backed by China's largest internet companies.

Still, China's startup support ecosystem remains a work in progress. Venture investors often look to monetize their investments quickly, reinforcing tendencies in their portfolio companies to go for short-term gains instead of transformational leaps (an area in which Silicon Valley excels). Most Chinese universities are also behind the curve when it comes to programs that generate and support Entrepreneur-led startups.

Not a lot of funding goes to early start-ups. Mainly the government invests in companies which are before the IPO.

The ideology is that if your company fails, you disappoint the country because the government invested in your company.

Despite several booms and busts in China's short venture capital history (the 'capital spring' of 2014-2015 gave way to the 'capital winter' of 2016, which then turned into the 'harvest year' of 2017), the number of private venture capital institutions has grown from 10 in 1995 to 500 in 2005 and 5'000 in 2015. The composition of venture capital sources has changed over time. Angel investments became abundant in 2014-2015, as a large number of wealthy individuals joined the VC fray. With the tightening in 2016, more start-ups turned to the newly established Third New Board for financing.

The 13th Five Year Plan Guiding government strategy for the 2016-2020 period, the 13th Five Year Plan prioritizes indigenous innovation, the achievement of technological self-sufficiency, the control of standards, and an expanded government role in the market. The industries it prioritizes overlap with those targeted in Made in China 2025. ⇒ The 14th Five Year Plan (2021-2025)

Made in China 2025 Made in China 2025 (MIC 2025) is an industrial policy designed to advance China's global leadership in manufacturing by promoting indigenous innovation, domestic brands, domestic standards, domestic production, the control of data. Its scope reasserts the government's role in central economic planning in ways that favor domestic companies over foreign ones in strategically selected sectors. One of its many objectives is the development of national corporate champions that will one day become global market leaders. It does this in part by setting global sales and market share targets for Chinese products, backed by directed government resources. These resources can be used to fund foreign technology acquisitions, among other purposes.

National Innovation-Driven Development Strategy Outline Products by the Central Committee of the Communist Party and the State Council in 2016, the Outline lays out China's science and technology plans and policies, promoting objectives similar to those of MIC 2025.

| | Switzerland |  | China |  |
|-----------------|--|---|-------|---|
| Strategic Level |  <p>Switzerland: the most innovative country in the world, ranked No.1 for 9 consecutive years on the Global Innovative Index</p> | | | |
| Asset Level |  <p>High-quality assets: 99% of tech-driven enterprises are SMEs/start-ups. The 5-year survival ratio of ETH spin-offs is as high as 92%.</p> <p>Limited European markets: many choose to enter USA, while few choose China or Asia</p> | | | |
| Capital Level |  <p>High demand for VC capital: many cutting edge and high-tech start-ups face funding gaps</p> <p>Conservative Capital: due to the cultural influence, the capital development is limited by its risk preference.</p> <p>Adequate Capital: after years of capital bubbles, capital tends to pursue high-quality projects</p> <p>Sufficient risk tolerance and strong operational capacity: the capital has strong capacity in technology transfer, packaging and operation</p> | | | |

Figure 13: When bottom-up meets top-down

8.5 Opportunities

See lecture Slides.³

China's consumption growth over the next 15 years might be comparable with that of the US and western Europe.

- Wealth management
- Discretionary consumption
- Health
- E-commerce
- FinTech

³<https://xyotta.com/cfiles/1233>

9 Knowledge and economic growth. A history of discovery, invention and innovation.

9.1 On the nature of economic growth

How to measure economic growth Basics:

- The output of an economy, in a specific country, over a certain period, is measured in terms of GDP - Gross Domestic Product.
- GDP gives the monetary value of final goods and services - that are those bought by the final user (net of intermediate consumption)
- The simplest measure of economic growth is the annual increase of GDP.
- But it is better to correct for changes in inflation and population and use the annual increase of real GDP per capita as a proxy for economic growth.

GDP is a very crude measure: It only counts transactions that can be given a monetary value. Here are a few examples of what is excluded from GDP:

- Unpaid household or voluntary work (on the positive side)
- So-called externalities like environmental destruction and pollution (on the negative side).
- Free digital goods like online search engines and new digital commons like Wikipedia or social media.

GDP is a short-term measure: It only considers monetary transactions and flows and as such totally ignores capital assets of all kinds such as the depletion of resources or loss of biodiversity, nor does it account for the improvement, decay, or even destruction of infrastructure or the value of human and social capital.

For example, the destruction of assets in wartime will not show up in GDP, but the 'consumption' of weaponry and the reconstruction after the war will boost GDP growth.

Economists understand little about the causes of growth

- growth is a consequence of capital accumulation (Solow, Swan, ...)
- availability of land and resources... (taken for granted in a class of economic models)
- growth as a consequence of (Cobb-Douglas) relations between labor, capital and technology; endogenous growth theories (Romer, Kramers, ...)
- growth made possible by legal and enforced framework (property rights)
- cultural and financial incentives for private efforts and innovations
- role of government, quality of governance and trust
- anti-corruption...

Exponential growth in the aggregate, with a rich underlying dynamical process Using modern data analysis techniques, Lera and Sornette proved that economic growth is bimodal:

- With one regime of expansion with strong growth, and another regime of consolidation with low growth or decline.
- The system naturally switches between these two regimes in one single dynamical process.
- In this view, growth and consolidation are two sides of the same coin.

Secular bipolar growth rate of the real US GDP per capita. A long term average growth rate of real GDP per capita of 2% per year is obtained by regime shifts between regimes of high growth (~ 3% per year) and regimes of low growth (< 1% per year).

Structural characteristics of growth: regime shifts and bimodal patterns

Lesson 1: Growth occurs in cycles and there is persistent hubris in extrapolating the high-growth regimes

It is important to realize that:

- The strong-growth modus is seen at the norm and the healthy state of economy, and the low-growth as an aberration and a symptom of disease that needs to be cured.
- Therefore, we always extrapolate the high-growth regimes.
- However, growth is a single bimodal process of overshooting during boom followed by correction and consolidation.
- The correction is as much part of the process as the boom.

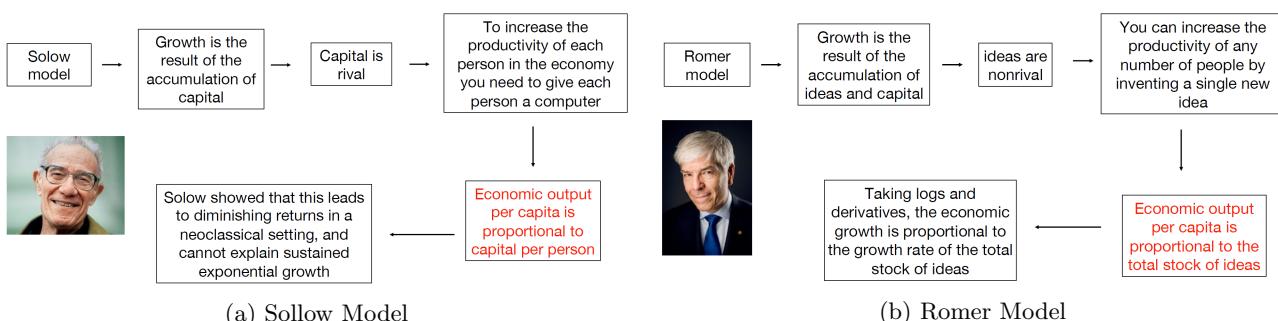
To explain where the coarse-grained long-term exponential growth comes from, we must first make a distinction between things and ideas, rival and nonrival goods.

Things versus ideas Things (objects, goods) are rival:

- As more people drive on a highway or use water for irrigation, there are fewer of these goods to go around...
- To increase the productivity of each person in an economic system using things (like a computer), you need to give each person such a thing. Economic output per capita, under such conditions, is proportional to the capital per person.
- in a closed economy, capital is subject to diminishing returns: 'The first barrel of fertilizer does wonders for a plot of land; the tenth only burns the crop.'
- This leads to a kind of steady-state, end-of-growth, unless exogenously something happens (e.g. technological change)

Ideas, in contrast, are nonrival:

- As more and more people use the Pythagorean theorem of the Java programming language, there is not less and less of the idea to go around.
- Ideas are not depleted by use, and it is technologically feasible for any number of people to use an idea simultaneously once it has been invented.
- You can increase the productivity of any number of people in an economic setting by inventing a single new idea. Economic output per capita, under such conditions, is proportional to the total stock of ideas. Taking logs and derivatives, the economic growth is proportional to the growth rate of the total stock of ideas.



Endogenous growth theory

- Economic growth is proportional to the growth rate of the overall stock of ideas.
- The overall stock of ideas grows with the increase of resources allocated to finding new ideas (people, capital,...)

- But it plateaus when ideas become harder to find (S-curve, logistical process...)
- The economy can only grow at a constant rate over the long run if research productivity (output/input, or results/investment) is constant.

In the following parts, we will zoom in on the following three questions:

- Are ideas harder to find?
- What exactly is 'knowledge'?
- Is there a constant rate of knowledge accumulation?

9.2 On the productivity of research

Discussing question 1: 'Are ideas harder to find?'

Despite vast increase in time and money spent on research, progress is barely keeping up with the past. What went wrong?

Number of PhD students increase and more is invested in research. On the surface, this is encouraging. But for all this increase in effort, are we getting a proportional increase in our scientific understanding? Or are we investing vastly more merely to sustain (or even decline in) the rate of scientific progress?

Economic growth (e.g. 2% or 5%) = Research productivity (falling) × Number of researchers (rising)

To have a constant research productivity, the effective number of researchers and the US TFP growth should behave similarly. It turns out that we need more than 20× more research capacity (input), to sustain a declining productivity (output).

Are ideas getting harder to find? In a paper in the American Economic Review, Bloom et al. give some compelling evidence:

- Moore's law: 'the number of researchers required to double chip density today is more than 18 times larger than the number required in the early 1970s... Research productivity in this case is declining sharply, at a rate of 7% per year.'
- Research productivity for crop seed yields and mortality improvements associated with cancer and heart diseases declines at a rate of 5% per year.
- Looking at firm-level data, research productivity declines at a rate of 8-10% per year dependent on the data source.

But continuous increase in R&D investment Over the past 70 years, the non-financial business debt in the U.S., as a fraction of GDP has increased from 40% to 140%. However, the contribution of investments to GDP has hovered between 15% and 20%.

Where has the increasing debt of American businesses been used for, if not for CAPEX and fixed assets? The most probable answer is that this debt is used to finance goodwill (e.g. from M&A activity) and intangible assets (R&D, patents,...)

9.3 On the nature of knowledge

Discussing question 2: 'What exactly is knowledge?'

9.3.1 What is "knowledge"?

What is the difference between discovery, invention and innovation?

Discovery The first-time recognition of something already existing:

- A thing: a new mine or an oil well, a continent, an island, a moon, planet, star, a fundamental particle (such as the electron or a neutrino)...
- An idea: an insight, like the discovery of a fundamental law of nature.

The result of a process of exploration:

- A high-risk endeavor into the unknown
- Willingness to employ substantial expenses without any certainty for future results or returns.

To use the words of the opening lyrics of the Star Trek television series, discovery is 'to boldly go where no man has gone before'.

The challenges of exploration According to Herbert Simon exploration requires:

- tolerance of ambiguity
- patience: learning-by-doing, accumulation of knowledge, trial-and-error
- luck / serendipity
- persistence / diligence
- 'intuition': use of smart heuristics

It is a high risk endeavor, where the payoff is almost impossible to estimate.

Invention The creation of something new:

- A thing: a mechanical machine like a steam engine, a scientific instrument like a microscope
- An idea: a mathematical algorithm, like artificial intelligence, or chemical process like the Haber-Bosch ammonia synthesis to produce fertilizers, or the Bessemer process to decarbonize iron in the production of steel.

The result of a creative process:

- Engineering
- often combined with stubborn trial-and-error tinkering
- and a large dose of luck

Innovation Combining existing things and ideas in a novel way to:

- Solve a problem,
- optimize a process
- or bring a new products or service to the market.

The result of a process of exploitation:

- Taking advantage, by doing combinatorics, of prior creative inventions and explorative discoveries
- Low (or at least known) risk endeavor into charted territory
- where one can make a decent estimation of the prospect of success

9.4 How do we innovate, invent or discover?

How to understand the incentives?

The whole is greater than the sum of its parts $R \sim c^\beta$ where the production R is defined as the total number of commits measured per 5-day time window for the Apache Web server and c is the number of active contributors in the same 5-day time window. β decreases with increasing number of developers.

Six design principles to help managers deal with the challenge of Productive/Creative Bursts.

- 1) transparency
- 2) bottom-up incentives and self-censored clans
- 3) emergent technology
- 4) problem front-loading
- 5) distributed screening
- 6) Modularity

The skill-success gap Mechanisms of Luck

- Gibrat's law, proportional growth, and the Matthew effect
- Winner-takes-all
- Adverse selection
- Male-male competition and evolution
- Big statistic replication crisis
- Hyped big data, artificial intelligence, and machine learning

Skill versus luck

$$\frac{dS_t}{S_t} = \mu dt + \sigma dW_t \quad , \quad \ln(S_t) \sim \left(\mu - \frac{\sigma^2}{2} \right) T + x_i \sigma \sqrt{T}$$

- S , the size of a firm
- μ , the growth rate
- W , Wiener process, stochastic random noise
- σ , volatility
- μ_{skill} , the mean of the skills of the N agents
- σ_{skill} , the standard deviation of the skills of the N agents
- μ_{luck} , the mean of the luck of the N agents
- σ_{luck} , the standard deviation of the luck of the N agents.

There is a characteristic time T^* at which skill and luck will contribute equal the outcome of the GBM process. At that time T^* satisfies $\mu T^* = \sigma \sqrt{T}$, yield $T^* = \left(\frac{\sigma}{\mu}\right)^2$.

Sharpe ratio - see lecture slides 26.05⁴

⁴<https://xyotta.com/cfiles/1236>

9.5 The industrial revolutions, four waves of industrial innovation

Is there a constant rate of knowledge accumulation?

Industry 1.0: The Industrial Revolution begins. Mechanization of manufacturing with the introduction of steam and water power.

Industry 2.0: Mass production assembly lines using electrical power.

Industry 3.0: Automated production using electronics, programmable logic controllers (PLC), IT systems and robotics

Industry 4.0: The 'Smart Factory'. Autonomous decision making of cyber physical systems using machine learning and Big Data analysis. Interoperability through IoT and cloud technology.

Industry 1.0 The industrial revolution (1760-1840)

Technology:

- Mechanization of manufacturing with the introduction of machine tools and steam power
- Mainly focused around the textile industry (cotton, wool, silk) e.g. spinning jenny

Energy:

- Beginning of the use of coal to power steam engines (steam power), in addition to muscular power (animals and humans) and traditional biofuels.

Geography:

- Originally started in the UK

Infrastructure:

- Networks of canals and improved waterways
- Paved 'macadamized' roads (John McAdam)
- First introduction of railroads in the UK (ending in the Railway Mania of the 1840s)

Industry 2.0 The technological revolution (1870-1910)

Technology:

- Electricity: steam turbine, generator, transformer, engine, incandescent bulb, light
- Steel (Bessemer process)
- Combustion engine
- Chemistry: synthesis of new materials and chemical products

Management:

- Economy of scale: It is cheaper to manufacture products in large quantities
- Vertical integration of the supply chain from raw materials (e.g. iron ore and coal) to final product (e.g. steel railway track)
- Scientific management (Taylorism): new empirical organization methods to improve efficiency and labor productivity in large scale businesses that operate over vast areas.

Geography:

- US, UK, Continental Europe

Energy:

- Coal and the birth of the high energy society

Infrastructure:

- Networked house (electricity, sewage, streaming water, telephone, central heating, etc)
 - Electrified underground railways (Paris Métro, London Tube, Berlin U-Bahn, ...)
 - Linking of existing railway networks to allow for long-distance travelling (e.g. Paris-Istanbul with orient express, Moscow-Vladivostok with Trans-Siberian Railway, ...)
 - Transatlantic telegraph cable
 - Transcontinental steamship routes
 - Sea canals (Suez, Panama)
 - City planning
-
- New structural forms with the application of new engineering techniques and materials such as glass and steel.
 - The rise of the modern city: straight boulevards, buildings with equal heights, parks and squares, new sewer systems, infrastructure for fresh drinking water...

Industry 3.0 The electronic revolution (1947-20xx)

Technology:

- PLC (Programmable Logic controllers)
- Computers (transistor, Integrated circuits, computer chips, microchips)
- Software and computer programs, user interfaces
- Robotics
- Mobile phones / smartphones

Infrastructure

- Automobile: Interstate highway systems
- Aircraft: Jet Age (aircraft powered by turbine engines), Long-distance commercial flights
- Digital: internet, worldwide web
- Mobile

Energy

- Oil and gas
- Nuclear

Phase 1: Mainframe computers connected through ARPANET (US department of defense) in TCP/IP protocol
→ internet mainframe

Phase 2: Desktop, laptop, tablets and smartphones connected in WWW (HTMP - HyperText Markup Language, invented in CERN) → internet of people, data and services

Industry 4.0 The cyber revolution (20xx - ...)

Phase 3: Cyber Physical Systems → internet of everything

People to people, people to machines and machines to machines

Technology: Cyber physical systems: physical and software components are deeply interwined

- Machine to machine technology
- Smart: Things measure, analyse and act autonomously
- Self-organization of technology, machines, human beings...
- internet of things
- Sensors
- Artificial intelligense, algorithms, big data analysis
- Augmented reality
- Additive manufacturing
- Cloud computing

9.6 A critical assessment of the industry 1.0 : 4.0 framework - The Chinese case

- It is very much Western-centric and describes technological progress as a continuous and steady process, from industry 1.0 up to industry 4.0, like the different deployments of a software package.
- In reality, progress (in technology, economy, society,...) is discontinuous and punctuated

Han Dynasty in China (207 BCE - 9 CE) The achievements of the Han dynasty in the field of science and technology were concentrated in hydroproject, architecture, mathematics, calendars and other technological fields, Han dynasty witnessed some of the most significant advancements in premodern Chinese science and technology. 'The consatenation of Han advances laid strong technical foundations for the development of the world's most persistent empire - which was, until the 18th century also the world's richest economy...'

Boreholes and mining shafts (206 BC - 220 AD) Borehole drilling has a long history. By at least the Han Dynasty, the Chinese used deep borehole drilling for mining and other projects. The Chinese method of deep drilling was accomplished by a team of men jumping on and off a beam to impact the drilling bit while the boring tool was rotated by buffalo and oxen. By the first century BC, Chinese craftsmen cast iron drill bits and drillers were able to drill boreholes up to 1500 m deep. It wasn't up until the 19th century that Europe and the West would catch up and rical ancient Chinese borehole drilling technology.

Hydraulics (206 BC - 220 AD) By the Han Dynasty, the Chinese developed various uses for the waterwheel. In his Balanced Discourse, the philosopher Wang Chong first described the square-pallet chain pump that could pump water and other substances. Their primary use was for lifting water into irrigation ditches, but chain pumps were also used in public works programs, such as when Zhang Rang used them to lift water into pipes. The water was used to provide the capital Louyang with clean water. In 31 AD Du Shi is credited with being the first to apply hydraulic power to operate bellows (air-blowing device) in metallurgy. This is a great invention in ancient China and the history of mechanical engineering, about a thousand years earlier than Europe.

The Seismograph (132 BC) The Han court was responsible for the major efforts of disaster relief when natural disasters such as earthquakes devastated the lives of commoners. Zhang Heng, an early Chinese scientist, created the first device for detecting distant earthquakes had occured in a location indicated by a specific cardinal or ordinal direction, which he introduced in the Han court in 132 AD. Its design was simple - an urn equipped with a pendulum. When it picked up a vibration, it dropped a ball from the mouth of a metal dragon into a metal frog, creating a loud clang. The first time that happened, nobody in the court reportedly felt anything, but a few days later, a messenger from a villate 400 miles away arrived to inform the emperor that an earthquake hat occured there.

The Wheelbarro (100 BC) The Wheelbarrow was developed in China perhaps as early as 100 BC. It can accommodate a much larger wheel, thus reducing the rolling resistance, and by having the wheel almost directly under the load it reduced the weight on the user's arms.

The Invention of Paper (105 AD) Cai Lun, an eunuch in the Han court in 105 AD, is credited as the inventor of the first really high-quality writing paper, which he fashioned by crushing and combining tree bark, hemp, linen rags, and scraps from fishing nets and then treating the mixture with lye to break it down into finer fibers.

Longshou Canal (120-111 AD) The Longshou Canal was built in 120 BC - 111 BC during the Han Dynasty, which is the first underground canal in China's history with more than 5 km, the Longshou Canal making use of the shaft-tunnel method. Its completion allowed irrigation of more than 40,000 hectares of saline land and increased the yield of its farmland by more than 10 times. This hydropower project spread to Central and Southwest Asia through the Silk Road. The Longshou canal has provided valuable experience for the world's water conservancy industry.

Gunpowder weapons in the Song dynasty (969-1044 AD) The earliest-known existent written formulas for gunpowder come from the Wujing Zongyao text of 1044, which described explosive bombs hurled from catapults. The earliest developments of the gun barrel and the projectile-fire cannon were found in late Song China. These 'fire-lances' were widespread in use by the early 12th century, featuring hollowed bamboo poles as tubes to fire sand particles (to blind and choke), lead pellets, bits of sharp metal and pottery shards, and finally large gunpowder-propelled arrows and rocket weaponry.

Hydraulic-powered astronomical clock tower Created by Su Song of the Song Dynasty in 1088 AD, it has three functions of observing the movement of the celestial bodies, demonstrating the changes in the sky, and accurately telling the time. It is the oldest astronomical clock in the world, representing the wisdom of polymaths and mechanical engineering of the Song Dynasty.

Jiaozi - The first paper money in history (1023 AD) Jiaozi, the earliest paper money used in the world, first appeared in the Sichuan region and was issued in Chengdu in 1023. In the beginning, the Jiaozi was actually a certificate of deposit, with the development of the market economy, the use of Jiaozi became more and more widespread, and in a short time it turned from a commercial credit certificate into an official legal currency with all the basic elements of modern paper money. Compare with western, the first government-issued paper money in the western world was in the late 17th century, more than 600 years after China.

9.7 A critical assessment of the industry 1.0 : 4.0 framework

Are the 4 different periods equal? Do they represent the same amount of "progress"? Maybe some inventions are more important than others?

Clean water and better hygiene lowered the death rate extremely. Older inventions such as amnesthetics is much more important than for example VR goggles for user experience. New inventions replaced older ones. Fake news are nothing new.

9.8 Conclusion

We discussed the following three fundamental questions.

- Are ideas harder to find? Yes
- What is the meaning of knowledge? Semantics do matter, knowledge itself has a fine-grained structure and should be disentangled into discovery, invention and innovation.
- Is there a constant rate of knowledge accumulation? No, it follows a complex process with ruptures, paradigm shifts, revolutions

It seems that the puzzle of economic growth has not been solved completely yet. And maybe a next step forward could be found through a better understanding of the structure and the dynamics of the knowledge accumulation process.

9.9 In our research group, we are trying to contribute to solving this puzzle. Here are some very recent results

Is there a constant rate of knowledge accumulation?

- We assembled a priority dataset of great inventors and discoverers over the past two millennia.
- You can see peaks in the graph during the industrial revolutions

Knowledge is not homogeneously distributed in space or time and across scientific disciplines

- In time, a rich pattern of waves can be observed coinciding with industrial and technological revolutions and scientific paradigm shifts.
- In space, we see that the UK has been the major participant in the three industrial revolutions from the past 250 years, in the first half of that period, the European Continent was its main challenger; in the second half it was the US. It is eye-opening to see that European Continent's steady decline since the 1900s, except perhaps in biology, medicine and genetics.
- Across scientific disciplines, we see a general superiority in physics, mathematics and astronomy, a long-term decline in Chemistry, and a strong increase in biology, medicine in genetics between 1910 and 1970.

Since 1970 all disciplines are in decline across all geographical regions. Our data would suggest that industry 4.0 is fully driven by innovation, and that the rate of discovery and invention is in a secular decline. Could this be one of the fundamental drivers behind dynamics of the Fool's Gold Age?

9.10 How to quantitatively formulate the problem of exploitation of an existing set of invention,innovation and exploration

What is the investment universe?

- The vast majority of papers on portfolio selection starts with a sentence of the form 'The investment universe consists of one risk-free and N risky assets'.
- In practice, even if N is large, it is arguably not the case that the $N + 1$ assets present in the specified investment universe cover every conceivable investment opportunity for the agent. Large investors are continuously looking for new investment opportunities (private investment, start-ups, crypto-assets, etc)
- Rather, these are the investment opportunities which are salient to the agent and well understood in terms of their relevant distributional properties.

Exploration of new investment opportunities

- We propose an extension of the classical setting with a fixed investment universe by giving the agent the option to explore for new investment opportunities.
- If this option is exercised, the agent chooses to devote a part of his/her wealth for exploration.
- Exploration results in the discovery of a new asset, whose distribution properties depend on the amount devoted to exploration in a way that the asset becomes more attractive to the agent when a larger amount is devoted to exploration.
- After discovery of the new asset, the agent optimizes her preferences over the resulting terminal wealth.
- trade-off between exploration and exploitation

Investment setting

- We consider a single-period model of an agent with mean-variance preferences.
- Classical model: fixed investment universe \mathcal{U} consisting of a risk-free bond providing a deterministic return r_f and N risky stocks with random return $\bar{r} = (r_1, \dots, r_N)'$.
- Under mean-variance preferences, knowledge about the mean and covariance structure of the risky assets is sufficient for portfolio analysis. We assume that $r \in L^2(\mathbb{P})$ and let $\bar{r} := \mathbb{E}[r]$ and $\Sigma := \mathbb{E}[(r - \bar{r})(r - \bar{r})']$
- We suppose that Σ is positive definite and that $\bar{r} \neq r_f \mathbf{1}_N$, where $\mathbf{1}_N \in \mathbb{R}^n$ denotes the vector with all components equal to one.

Classical mean-variance optimization problem In the standard setting, an agent with initial wealth x_0 and target expected return $\mu \geq r_f$ solves classical mean-variance optimization problem

$$\min_{u \in \mathbb{R}^n, u_0 \in \mathbb{R}} u' \Sigma u \quad \text{such that} \quad u' \bar{r} + u_0 r_f = \mu x_0 \quad \text{and} \quad u' \mathbf{1}_N + u_0 = x_0 \quad (MV(\mu, x_0))$$

Recall the following constants associated with the investment universe \mathcal{U} ,

$$A = \mathbf{1}'_N \Sigma^{-1} \bar{r} \quad , \quad B = \bar{r}' \Sigma^{-1} \bar{r} \quad , \quad C = \mathbf{1}'_N \Sigma^{-1} \mathbf{1}_N \quad , \quad D = r_f^2 C - 2r_f A + B$$

which play a role in the explicit derivation of the optimal value and optimal solution to $(MV(\mu, x_0))$. The optimal value of $(MV(\mu, x_0))$ is given by $\sigma_{MV}^2 = \frac{(\mu - r_f)^2}{D} x_0^2$

Mean-variance with exploration

- In practice, the $N+1$ assets considered in $(MV(\mu, x_0))$ do not constitute the totality of available investment opportunities.
- In our model, the agent has the option to devote an amount $\kappa \geq 0$ for exploring new investment opportunities.
- If this option is exercised, the agent discovers a new asset with return $r_e(\kappa)$, expected return $\bar{r}_e(\kappa)$, and standard deviation $\Sigma_e(\kappa)$.
- Assumptions:
 - 1) The new asset is uncorrelated with assets in \mathcal{U}
 - 2) $\bar{r}_e(\kappa)$ and $\Sigma_e(\kappa)$ are known as a function of κ
 - 3) $\bar{r}_e(0) = r_f$ and that $\Sigma_e(\kappa) > 0$ for all $\kappa \geq 0$
 - 4) $\bar{r}_e(\kappa)$ is increasing and C^1 and Σ_e is decreasing and C^1 .

Mean-variance optimization problem with exploration The objective of the agent is to concurrently determine whether to exercise the option to explore for new investment opportunities and, if the option is exercised, an optimal amount devoted to exploration and an optimal allocation in the extended investment universe, while, if the option is not exercised, an optimal allocation in the existing investment universe.

If the option to explore is exercised, an agent with initial wealth x_0 and target expected return $\mu \geq r_f$ solves the mean-variance optimization problem with exploration

$$\inf_{\kappa \geq 0} \left(\min_{u \in \mathbb{R}^n, v \in \mathbb{R}, u_0 \in \mathbb{R}} u' \Sigma u + \Sigma_e^2(\kappa) v^2 \quad \text{such that} \quad u' \bar{r} + v' \bar{r}_e(\kappa) + u_0 r_f = \mu x_0 \quad \text{and} \quad u' \mathbf{1}_N + v + u_0 = x_0 - \kappa \right) \quad (MVE(\mu, x_0))$$

Fixed amount for exploration For a fixed $\kappa \geq 0$, we first consider the inner optimization problem of $(MVE(\mu, x_0))$, which we call the mean-variance optimization problem with a fixed amount devoted to exploration. We denote the optimal value of $(MVE(\mu, x_0))$ by $\sigma_{MVEF}^2(\kappa) = \frac{(\mu x_0 - r_f(x_0 - \kappa))^2}{D_e(\kappa)}$

Proposition: Consider an investment universe \mathcal{U} with associated A, B, C, D and let

$$A_e(\kappa) = A + \frac{\bar{r}_e(\kappa)}{\Sigma_e^2(\kappa)} \quad , \quad B_e(\kappa) = B + \frac{\bar{r}_e(\kappa)^2}{\Sigma_e^2(\kappa)} \quad , \quad C_e(\kappa) = C + \frac{1}{\Sigma_e^2(\kappa)} \quad , \quad D_e(\kappa) = D + \frac{(\bar{r}_e(\kappa) - r_f)^2}{\Sigma_e^2(\kappa)}$$

The problem $(MVEF(\mu, x_0; \kappa))$ has the unique solution

$$u = \frac{\mu x_0 - r_f(x_0 - \kappa)}{D_e(\kappa)} \Sigma^{-1}(\bar{r} - r_f \mathbf{1}_N) , \quad v = \frac{\mu x_0 - r_f(x_0 - \kappa)}{D_e(\kappa)} \frac{r_e(\kappa) - r_f}{\Sigma_e^2(\kappa)} , \quad u_0 = x_0 - \kappa - \frac{\mu x_0 - r_f(x_0 - \kappa)}{D_e(\kappa)} (A_e(\kappa) - r_f C_e(\kappa))$$

and the optimal value is given by

$$\sigma_{MVEF}^2(\kappa) = \frac{(\mu x_0 - r_f(x_0 - \kappa))^2}{D_e(\kappa)}$$

One must put a significant amount at risk The optimal value of $(MVEF(\mu, x_0; \kappa))$ depends only on the distributional characteristics of the newly discovered asset through the Sharpe-ratio of the newly discovered asset, which we denote by

$$S_e(\kappa) = \frac{\bar{r}_e(\kappa) - r_f}{\Sigma_e(\kappa)} , \quad \kappa \geq 0$$

Corollary: Suppose that $S'_e(0) < \infty$ and let $\mu > r_f$. There exists an $\epsilon > 0$ such that $\sigma_{MVEF}^2(\kappa) > \sigma_{MVEF}^2(0)$ for any $\kappa \in (0, \epsilon)$.

"One must put a significant amount at risk in order to harvest the potential benefits of exploring for new investment opportunities."

Dependence on the existing investment universe "It is not optimal to explore when the existing investment universe is good enough"

Dependence on initial wealth "The rich perform better."

Do the rich actually perform better?

- The empirical evidence on the effect of scale on performance in the fund industry is mixed or shows even an inverse relationship between fund size and performance.
- At the level of family of funds find that the size of the family is positively related to the performance
- Investment returns achieved by larger university endowments outperform those of smaller endowments.
- For pension funds, investment performance is increasing in the scale of the funds.
- Larger nonprofit endowment funds significantly outperform smaller ones based on tax-return data from all public in the US over the 2009-2017 period.

Example See Lecture Slides 26.05

Directions for future research

- 1) Multiple new investment opportunities
 - Decide on the number of new investment opportunities to explore for
 - Nonconvex integer programming problem
- 2) Uncertainty about the distribution of the newly explored asset
 - The distributional properties of the newly discovered asset are now known in advance as a function of the amount devoted for exploration. Instead, they are drawn randomly.
 - Needs to be careful about dynamic consistency (concurrent vs sequential determination of amount devoted and strategy)
- 3) Dynamic portfolio optimization
 - Decision variables: Stopping times (when to explore), amounts devoted for exploration (how much to explore), and investment strategies on an expanding universe
 - Challenging new optimal stopping problem

10 Humanity in the Anthropocene

10.1 The Secret History of Silicon Valley

- Terman/Stanford/Government responsible for entrepreneurial culture of Silicon Valley.
- Military primed the pump as a customer for key Valley technologies
 - Semiconductors, computers, Internet
 - But very little technical cross pollination
- Venture Capital turned the valley to volume corporate and consumer applications
- Berkeley continued its focus on Big Science and National Labs

10.1.1 Story 1: WWII The First Electronic War

The German Air Defense System: The Kammhuber Line

- Integrated Electronic air defense network
- Protection from British/US bomber raids (Warn and detect, target and aim, destroy)

British/American Air War in Western Europe 28'000 active Combat Planes, 40'000 Allied planes lost or damaged beyond repair: (46'000 planes lost by the USSR in the East), 160'000 Americans and British killed, wounded or captured.

Mammoth Early Warning Radar 200 mile range, 100' wide, 33' high, 1st phased-array radar, Operational 1942, 20 built

Wasserman Early Warning Radar 150 mile range, Backbone of the German early warning network, steerable tower 190', operational 1942, 150 built

German Night-Fighters Airborne Intercept Radar, Directed to vicinity by ground radar, Allowed the german fighters to find the bombers at night.

By August 1941 only 10% of Britisch bombers got within 10 miles of their target.

10.1.2 Story 2: The Electronic Shield-Electric Warfare

Harvard Radio Research Lab (RRL) Signals Intelligence and Electronic Warfare

- Reduce losses to fighters and flak
- Find/understand German Air Defense (Electronic and Signals Intelligence)
- Jam/confuse German Air Defense
 - Radar Order of Battle
 - Chaff (strips of metal foil released in the air to obstruct radar detection)
 - Jammers
- Top Secret 800 person lab

Who ran this secret lab and became the Father of Electronic Warfare?

- Harward Radio Research Lab
- Director: Fredrick Terman - Stanford
- Stanford Professor of engineering 1926
 - encouraged his students, William Hewlett and David Packard to start a company
- Dean of Engineering 1946
- Provost 1955

10.1.3 Story 3: Stanford and the Cold War

Terman's Postwar Strategy

- Focus on microwaves and electronics (did not want to get left out in Government spending)
- Recruits 11 former members of RRL as faculty
- Set up the Electronics Research Laboratory (ERL)
 - "Basic" and Unclassified Research
- First Office of Naval Research (ONR) contract 1946
- By 1950 Stanford was the MIT of the West

RRL = radio research laboratory at Harvard

Microwave Valley - Stanford Spinouts There were many spinoffs from Stanford that focused on Microwaves. Especially microwave tube startups and other microwave components.

The Cold War and Stanford

- The Cold War battlefield moves 500 miles east
- Countermeasures, ELINT become critical
- Stanford becomes a center of excellence for the CIA, NSA, Navy, Air Force
- 400-person weapons lab in engineering department

ELINT = electronic intelligence

The Cold War is an Electronic War

- Russian air defense modeled after Germans
 - add surface to air missiles, fighter radar, IFF
 - Understand and defeat (ELINT)
- Soviet strategic missile and bomber threat
 - Monitor telemetry (SIGINT) to understand performance
 - Photo reconnaissance to find silo's and bombers
- Soviet Naval threat
 - Monitor and track soviet submarines
- Soviet Nuclear threat
 - Identify and understand production facilities

Identification, friend or foe (IFF) is a radar-based identification system designed for command and control. It enables military and civilian air traffic control interrogation systems to identify aircraft, vehicles or forces as friendly and to determine their bearing and range from the interrogator.

SIGINT = signal intelligence

Stanford joins the "Black" World

- Electronics Research Laboratory ("Basic" and Unclassified Research)
- Applied Electronic Laboratory (AEL) ("Applied" and Classified programs)
- Merge and become the Systems Engineering Lab (SEL) in 1955 (Same year Terman becomes Provost)
- Immediate, practical application of real world intelligence problems for CIA, NSA, NRO, Air Force
- Combined ERL components with advanced theory into complete SIGINT and Jamming systems
 - Usually prototypes turned over to contractors
 - At times, built one-off systems
 - Digital filtering, OTH (over the horizon), etc
- Use PhD students and staff (classified thesis!)
- Ultimately 800 person lab

Terman Changes the Startup/University Rules

- Graduate students encouraged to start companies
- Professors encouraged to consult for these companies
- Terman and other professors take board seats
- Technology transfer/IP licensing easy
- Getting out in the real world was good for your academic career
- Failure was accepted as part of the culture

Stanford/Military/Industry Ecosystem

- Stanford did basic research in electronics
- Stanford and SRI do applied research
- Microwave and systems companies in Silicon Valley produce equipment for the military

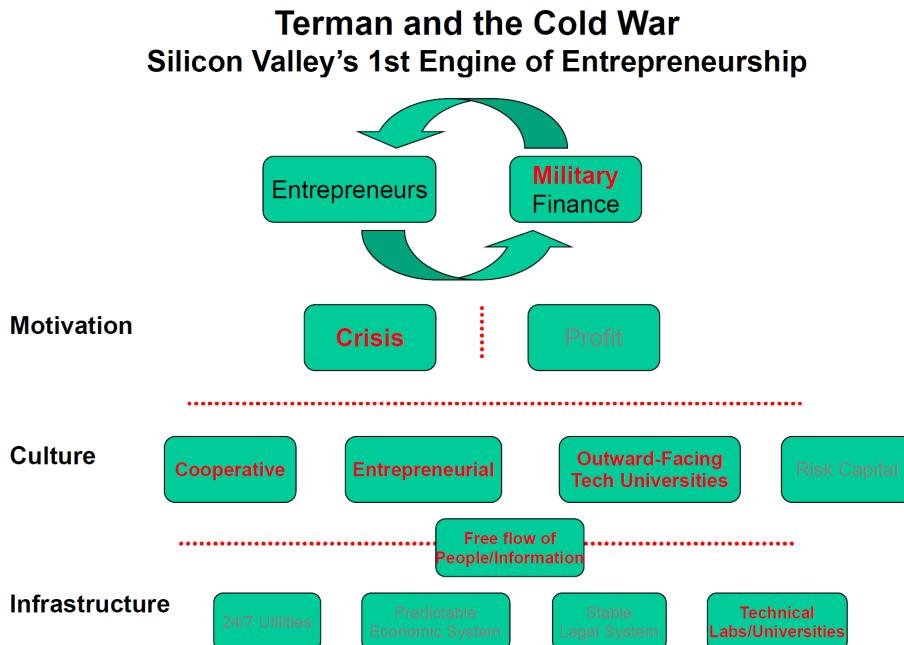
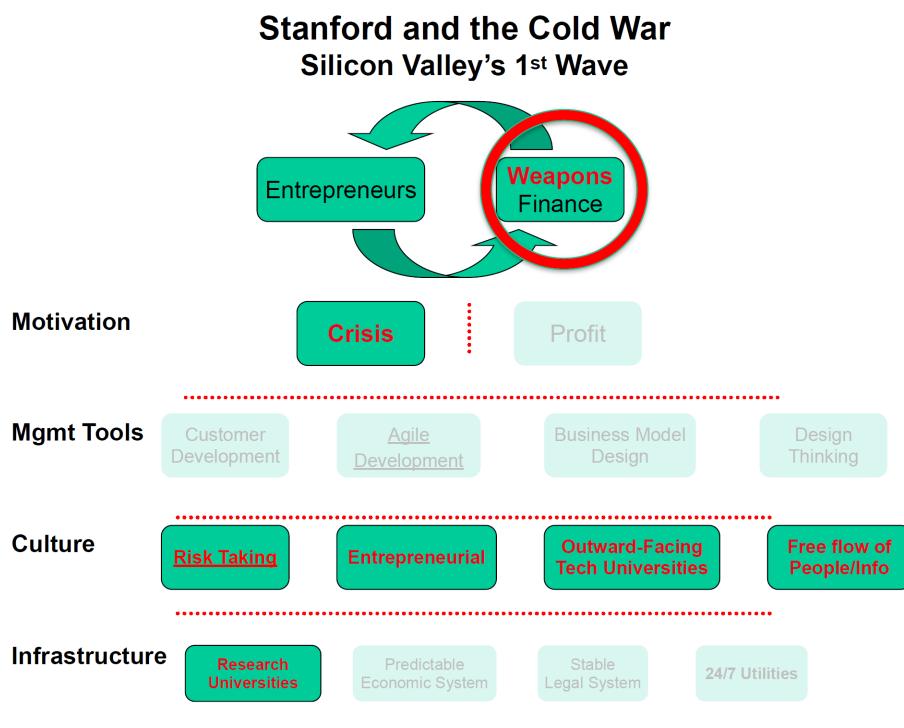
Terman's Strategy

1. Sit on every possible Military Advisory board
 - Build Network and relationships
2. Reach out to military customers to understand their needs. Then craft a prototype in Stanford's labs
 - generate revenue for the university and strengthen its military relationship
3. If the customer liked the prototype, encourage a student to found a company and manufacture at scale
 - inspired entrepreneurship (and hard work) in the students in the university's labs
4. Put a Stanford faculty (or Terman) on the board or as a consultant with the new company
 - This trained Stanford faculty in business and turned them into better teachers and researchers
5. Provide office space in the Stanford Industrial Park
 - This ensured that the startup stayed close and helped the entrepreneurial ecosystem reach a higher density

Consequences for Stanford

1. Stanford became the preferred contractor for ELINT and Electronic Warfare (EW) prototypes
 - Frederick Terman was a ELINT and EW gatekeeper
2. Stanford attracted talented students, military customers, and later, private investor ecosystem
3. Academic research in ELINT and EW was driven by customers' needs rather than being pushed by lab or the agendas of national research agencies
 - Terman as the first advocate for Customer Development

Microwave Valley - Systems



The End of Classified Work at Stanford

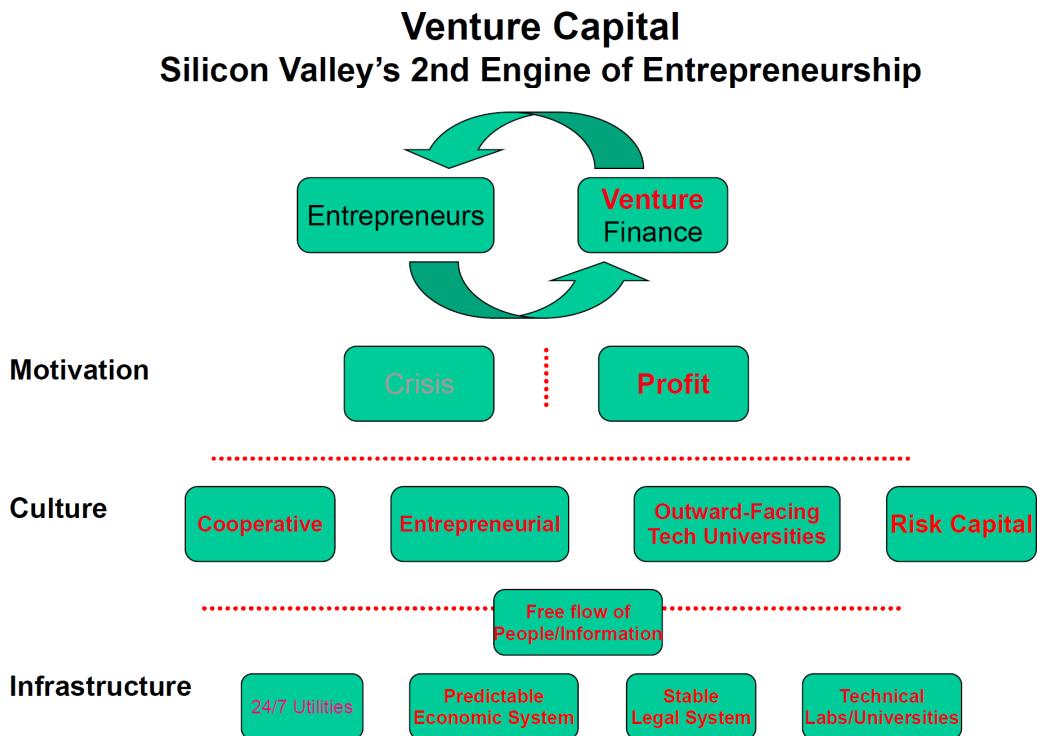
- In 1968, 35% of Stanford research funding in electronics was for classified work
- 50% of SRI's work was from DOD
- April 9, 1969 400 students occupy AEL

Shockley's Legacy

- Director of Navy anti-submarine warfare operations group at Columbia (1942-1943)
- Head of Radar Bombing training for Air Force (1943-1945)
- Deputy Director and Research Director of the Weapons System Evaluation Group in the Defense Department (1954-1955)
- Co-inventor of the transistor (Nobel Prize in 1956)
- Founded Shockley Transistor 1955
 - First semiconductor company in California

10.1.4 The Rise of Venture Capital - The Limited Partnership

- Raise money from pension funds, private universities, wealthy individuals - the limited partners
- Investment professionals manage the fund - the general partners i.e. the VC's
 - Compensate the general partners via the "2 and 20"
 - 2% management fee, 20% carried interest (i.e. of the profits)



10.1.5 Summary

- Terman/Stanford/Government responsible for entrepreneurial culture of Silicon Valley.
- Military primed the pump as a customer for key Valley technologies
 - Semiconductors, computers, Internet
 - But very little technical cross pollination
- Venture Capital turned the valley to volume corporate and consumer applications

Is there another "crisis" that will restart the valley's cycle of innovation? Or will we continue to be profit driven?

10.2 What is the State's role in the economy?

- a) Set 'level' playing field then get out of the way
- b) solve 'market failures'
- c) something more interesting?

The assumption: Private sector vs. public sector, The new view: not only fixing the market but also shaping it.
Market failure policies don't explain the advent of key General Purpose Technologies

- 'mass production' system
- aviation technologies
- space technologies
- IT
- internet
- nuclear power
- nanotechnology

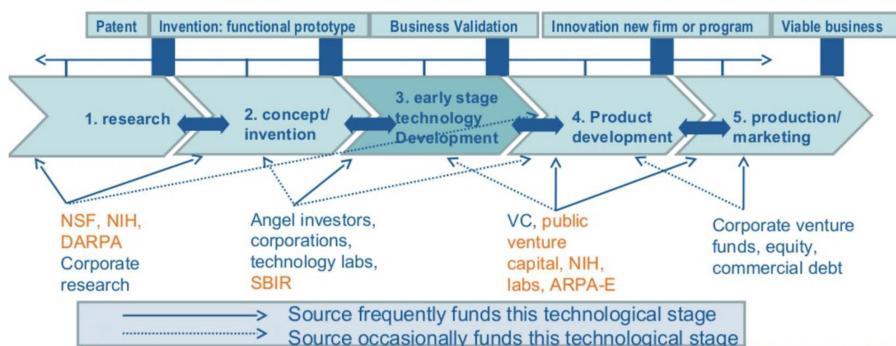


Figure 15: Mission oriented investments along entire innovation chain

Microchips powering the iPhone owe their emergence to the US military and space programs, which made up almost the entire early market for the breakthrough technology. In the 1960s, the government bought enough of the initially costly chips to drive down their price 50x in a few short years, enabling numerous new applications.

Cellular communication The early foundation of cellular communication lies in radiotelephony capabilities advanced throughout the 20th century with support from the US military.

Internet The technologies underpinning the Internet, which gives the "smart phone" its smarts, were developed and funded by the Defense Department's Advanced Research Projects Agency (DARPA) in the 1960s and 70s.

GPS was created/deployed in 1980s/90s by the military's NAVSTAR satellite program and still today maintained via public funds.

Multi-touch displays that makes using an iPhone so intuitive has the government's fingerprints all over it. The revolutionary interface was first developed by a brilliant pair of universities of Delaware researchers supported by NSF and CIA grants

SIRI was initially developed in DARPA.

10.3 The Social Bubble Hypothesis

"Enthusiastic supporters of an idea / a project / an opportunity weave a network of reinforcing feedbacks based on exuberant anticipation that lead to widespread endorsement and extraordinary commitment beyond what would be rationalized by a standard cost-benefit analysis."

How to engineer useful bubbles for innovation!

The social Bubble Hypothesis: "innovation accelerator"

Definition. A social bubble developing during a technological project is defined when several of the following symptoms are simultaneously present:

- (i) strong growth of presence in the media, newspapers, books, blogs, gossips, cocktails...
- (ii) flow of venture capital and Wall Street investments
- (iii) accelerated price growth of corresponding firms trading on organized stock markets
- (iv) proliferation of venture of all kinds

Three case studies so far: The US Apollo Program (1960-1969), The Human Genome Project (1990-2003), The FutureICT Project (2010-2013)

The Human Genome Project

- In February 2001, Celera and HGP scientists published details of their drafts, describing the methods used and offering analysis of the sequence
- Improved drafts were announced and presented to the public in 2003, filling the open gaps

Anticipations of the commercial and medical applications of the HGP were highly inflated. Today, it is acknowledged that insight into the genetic mapping and sequencing effort is only seen as a starting point for future research in biology and medicine. Contrary to claims during its development, the main fruits of the Human Genome Project have been accruing to the research community, and almost nothing to medicine and the general public. But indirect technological gains values at > 750 Billions USD by Obama's administration.

Future social bubbles?

- biotech and nanotech, genomics, proteomics, personalised medicine
- Apps revolution (like pre-internet boom)
- open and big data revolution
- Green tech revolution
- Gas and oil Fracking
- Space frontier
- Ocean frontier
- Nuclear energy technology revolution
- Bitcoin

”Salvation and Profit”: Deconstructing the Clean-Tech Bubble

- From 2004 to 2008, a bubble formed in clean technologies, such as solar, biofuels, batteries, and other renewable energy sources.
- This clean-tech bubble can be rationalised through the lens of the Social Bubble Hypothesis, which holds that strong social interactions between enthusiastic supporters weave a network of reinforcing feedbacks that lead to widespread endorsement and extraordinary commitment by those involved.
- Detailed synthesis of the development of the clean-tech bubble, its history, and the role of venture capital and government funding in catalyzing it.
- Underlying narrative that was fueling the bubble.
- Evidence that the clean-tech bubble constituted an example of an innovation-accelerating process.

The clean-tech bubble was clearly a social bubble: the narrative of a ”normal imperative” to combat climate change and achieve ”salvation”, the ballooning venture capital investments, and the massive government subsidies weaved a network of self-reinforcing spirals that led to over-optimistic expectations, excessive enthusiasm, and over-investments.

The question now arises whether the clean-tech bubble was - as it has been historically the case for a number (but not all) bubbles - accelerated the development, deployment, and diffusion of clean technologies. In other words, did viable commercial and industrial infrastructure and products emerge after the bust of the bubble?

Although the clean-tech bubble went burst, we can identify some factors that indicate that the bubble did indeed catalyze technological progress in clean and renewable energy technologies.

In essence, the clean-tech bubble of the mid-2000s catalyzed a massive decrease in cost by excessively funding research and development in different clean-tech sectors, such as solar or wind. While almost all of the clean-tech startups of the last bubble failed, the clean-tech bubble, by decreasing prices and funding innovation, massively de-risked clean and renewable energy technologies. Solyndra, for example, failed because it was trying to market a cutting-edge new solar cell, which ended up being too expensive when the design costs started to decrease. Today, solar or wind are no longer risky technologies and are now even cost-competitive with legacy energy sources, such as gas or coal. This decrease in costs and the elimination of technical risks of clean tech is now catalyzing more investment opportunities, which, in turn, attracts new entrepreneurs and investors, such as Softbank, Founders Fund, Sequoia Capital, Y Combinator, and the two funds that were already investing in first clean-tech boom-and-bust cycle, Kleiner Perkins and Khosla Ventures.

10.4 Certain to Win

John Boyd - USAF The fighter Pilot who changed the art of air warfare. Act fast and seem unpredictable. ”Forty-Second-Boyd”: He was dubbed ”Forty-second Boyd” for his standing bet as an instructor pilot that, beginning from a position of disadvantage, he could defeat any opposing pilot in air combat maneuvering in less than forty seconds. He never lost.

Developed the Aerial Attack Study: After the study was declassified, foreign pilots passing through Nellis took it home where it changed the way every air force in the world flies and fights. Even today, more than 40 years later, nothing substantial has been added to the Aerial Attack Study.

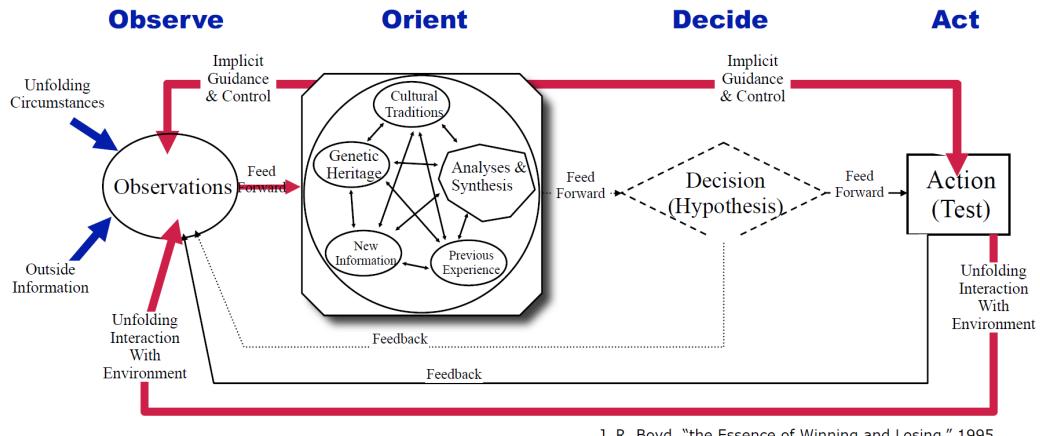
After a six-year assignment at Nellis, Boyd returned to college for another undergraduate degree. He went to the Georgia Institute of Technology where, one night while studying for an exam in thermodynamics, he had the epiphany that became his famous *Energy-Maneuverability Theory*, or E-M Theory, as it came to be known.

The E-M Theory changed everything that everyone thought they knew about fighter combat. It enabled fighter pilots to evaluate their energy potential at any altitude and at any maneuver. And, perhaps more importantly, the energy potential of their adversary. It changed forever the way aircraft are fought in combat.

Boyd then used E-M as a design tool. Until E-M came along, fighter aircraft had been designed to fly fast in a straight line or fly high to reach enemy bombers. The F-X, which became the F-15, was the first Air Force fighter ever designed with maneuvering specifications. Boyd was the father of the F-15, the F-16 and the F-18.

America has dominated the skies for the past 30 years because of John Boyd.

After he retired, he developed a theory of combat that, according to Vice President Dick Cheney who was Secretary of Defense at the time, was responsible for America's swift and decisive victory in the Gulf war.

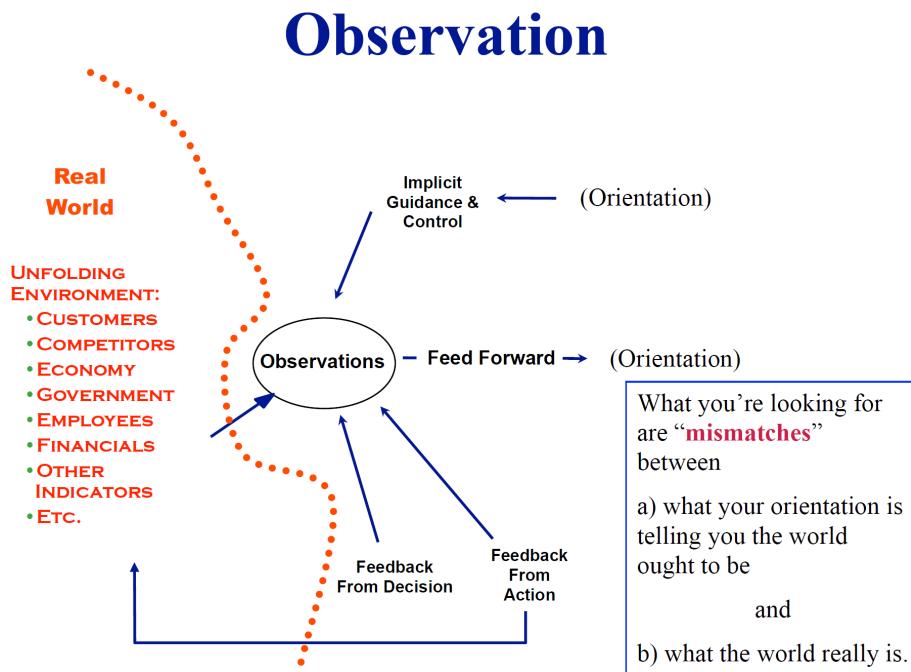


J. R. Boyd, "the Essence of Winning and Losing," 1995.

"Orientation is the *Schwerpunkt*." *Organic Design*, 16.

"Emphasize **implicit** over **explicit** in order to gain a favorable mismatch in friction and time (ours lower than any adversary's)." *Organic Design*, 22.

"Interaction permits vitality and growth, while isolation leads to decay and disintegration." *Strategic Game*, 29.



Wars don't always turn out as expected. Business doesn't either. But it's not inevitable.

Time is special

- Time is the only physical parameter with a direction (the "arrow of time")
- You don't have an unlimited supply.
- Once it's gone, it's gone.

- Sure sign you're not using Boyd's strategies: you try to solve problems by throwing more time at them.
- I may lose a battle, I will never lose a minute - Napoleon
- A time-compressed company does the same thing as a pilot in an OODA loop... It's the competitors who act on information faster who is in the best position to win.

Using time as a weapon: The "H-Y War" (1981-1983)

- Honda Motorcycles introduced or replaced 113 models, effectively turning over its entire product line twice.
- Yamaha, which also started about 60 models, was only able to manage 37 changes in product line over the same 18 months.
- Observation: As a result, Honda was able to incorporate (and test in the marketplace) a much wider variety of styling & technology. But that alone would not have been decisive.

Put it simple:

- Good news is dangerous
- Bad news is the only thing that will save you, if:
 - You find it before it finds you
 - You correct your orientation
 - You act upon it

What determines OODA loop speed?

- Ultimately, a moral climate/culture/environment that encourages people to use their initiatives to further the goals of the organization
- Under such a climate, people will solve the technical problems

Boyd's organizational climate: The principles of the Blitzkrieg

- Fingerspitzengefühl - Zen-like quality of intuitive understanding. Ability to sense when the time is ripe for action. Built through years of progressively more challenging experience.
- Einheit - Has the connotation of "mutual trust" and implies a common outlook towards business problems. Built through common experience. Fingerspitzengefühl at the organizational level.
- Schwerpunkt - Any concept that gives focus and direction to our efforts. In ambiguous situations, answers the question, "What do I do next?" Requires leadership.
- Auftragstaktik - Tell team members what needs to be accomplished, get their agreement to accomplish it, then hold them strictly accountable for doing it - but don't prescribe how. Requires very high level of mutual trust.

Flowdown: Schwerpunkt for manufacturing:

The Toyota Production System, quite simply, is about shortening the time it takes to convert customers orders into vehicle deliveries. This tells everybody in Toyota manufacturing: "When in doubt, take the action that has the biggest impact on order-to-delivery time".

Another Schwerpunkt:

Most CEOs are focused on achieving their financial and operational goals, and on executing a strategy. But Apple's Steve Jobs believed his company's ultimate advantage comes from its ability to make unique, or as he called them, "insanely great" products. Jobs's entire company is focused on that task.

Effective Forces play the Cheng / Ch'i Game

- Sun Tzu: "Making armies able to take on opponents without being defeated is a matter of unorthodox (Ch'i) and orthodox (Cheng) methods... give rise to each other like a beginning-less circle - who could exhaust them?"
- Boyd: "... to gain a feel for the ways the cheng / ch'i game has been (and can be) played."
- Can be played on multiple levels, i.e., if opponent knows we like cheng / ch'i, we can exploit that fact also (Hitler at invasion of France, 1944)