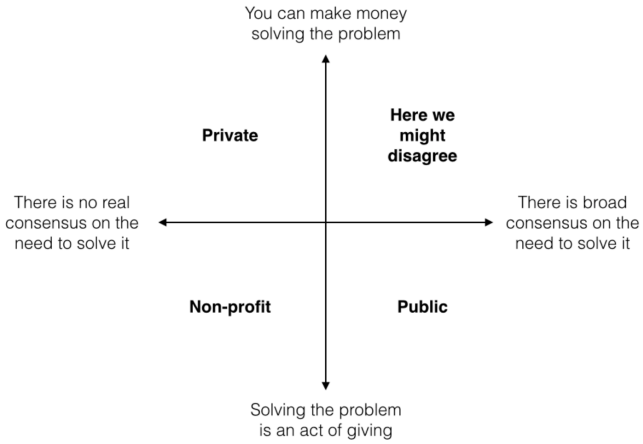
QPAM

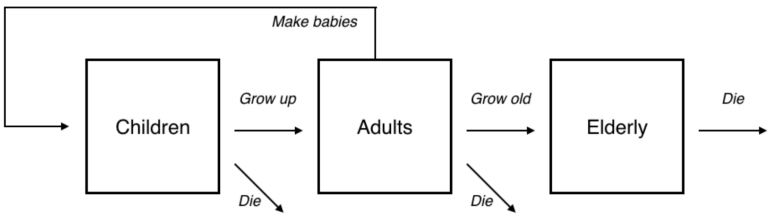
Problem Definition - Tony

- What is public policy?
  - It is a strategy or course of action that governments take
- **Policy Analysis**
  - Identify appropriate policy for tackling the identified policy problem
  - Find appropriate Policy Instruments
  - Appraising effects of Instruments
- Defining the Problem
  - Don't mix problems with consequences of other problems
- When should government solve problems?
  - Market failures and inefficiencies (Public goods, externalities, information asymmetries, monopolies)
  - Inequalities (economic, discrimination)
  - Things we expect governments to do and lack other institutions (Schools, Post,..)
- When you can't solve a problem
  - Narrow it down
  - Expand it
  - Which one to use depends if the problems are political are technical



System Dynamics - Oskar

- System Dynamics is an approach to understanding nonlinear behavior of complex systems over time by using stock flows, feedback loops and diagrams.



Investment Appraisal and CEA - Tobias

Important Concepts

- **Cash-flow (CF)**
  - Sum of expenses and revenues over a period of time (project's lifetime)
  - Nominal CF: non discounted
  - Real CF: discounted with private discount rate r
- **Discount Rate (r)**

$$real\ cashflow = \frac{nominal\ cashflow}{(1+r)^t};$$

r = discount rate
t = year of cash-flow

- represents the cost of capital or opportunity cost of capital
- how much could I earn with the money in a similar investment (similarly risky)
- Cost of capital depends on source of capital (Equity and Debt don't have same rate)

- **Capital Structure**
  - Indicates the share of debt and equity
- **Weighted Average Cost of Capital (WACC)**
  - combine capital structure and cost of debt and equity in one number.

$$r = WACC_{pretax} = \frac{E}{V} * k_E + \frac{D}{V} * k_D \quad (V = investment\ volume)$$

Profitability Indicators

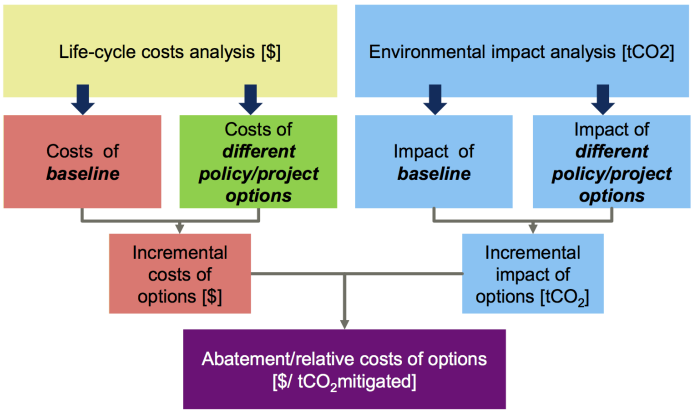
- **Payback Period (P)**
  - Time taken for a project to recover its initial investment
  - Usage:
    - Investment attractive if P < certain threshold (ex 5 years)
  - Problems:
    - Opportunity cost of Capital not considered —> **Don't use**
    - No integration of time-value of money
  - Advantages:
    - very simple to calculate
    - no discount rate needed
- **Internal Rate of Return (IRR)**
  - Rate (%) at which the investment has zero NPV
  - Solve NPV = 0 for rate r. Found r is IRR.
  - Express return rate of an investment
  - Usage:
    - IRR > cost of capital —> project more profitable than minimal needed return, do project
    - When two investments with same NPV, choose the one with highest IRR
  - Problems:
    - Cannot compare projects with different size (different initial investment costs, CF etc)
    - Problematic when lifetime of alternatives are different
    - Use with extra caution or **Don't use**.
  - Advantages:
    - No discount rate needed for calculation
    - considers opportunity cost
- **Net Present Value (NPV)**
  - Sum of discounted CF over life time minus upfront investments
  - A project's Net contribution to wealth
  - Expected money to be earned by investment at today's rate
  - Profitability Threshold is NPV = 0
  - Usage:
    - If NPV > 0 do the project. Means that you earn more than your cost of capital.
  - Problems:
    - Two projects with same NPV could have very different return on investment —> PI
    - Need discount rate to calculate
    - Not great when comparing projects of different sizes
  - Advantages:
    - Considers opportunity cost
    - Possible use of dynamic discount rates —> **Use**
- **Profitability Index (PI)**
  - NPV over initial investment cost

- Usage:
  - If PI positive, profitable, do the project
  - Choose alternative with highest PI
- Problems:
  - Don’t know how much you actually earn
  - Combine with NPV
- Advantages:
  - Gives idea of return on investment
  - don’t need discount rate —> **Use**

Life-Cycle Cost (LCC) and Levelized Cost of Electricity (LCOE)

- **LCC**
  - For calculating Cost-Effectiveness of different options.
  - LCC = NPV of only the costs (discounted)
  - LCC = CAPEX + sum_{t=0}^{T} OPEX/(1+r)^t
- **LCOE**
  - It is the constant electricity price that would be required over lifetime of a plant to cover all operating expenses, payment, debt.
  - LCOE is the discounted LCC normalized by the discounted expected power output over the lifetime of the project
  - LCOE = LCC / (sum_t kWh_t)
  - **Application:**
    - Good for calculating Feed-in Tariffs
    - LCOE good for comparing technologies (even with different life times)
    - Need to compare projects with the exact same output.

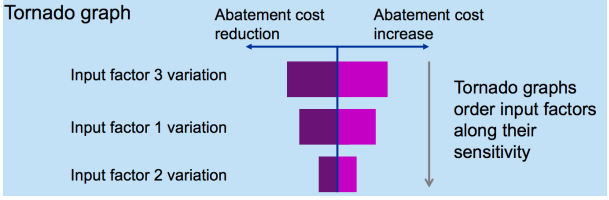
Cost Effectiveness Analysis (CEA)



- Objective:
  - Reach certain target at minimal cost (when goal is the target)
  - Achieve maximal impact for a given cost (when budget constrained)
- **Incremental Costs**
  - Additional costs of a project compared to the baseline (can be negative)
- **Environmental Impact Assessment:**
  - Indicators:
    - tCO2, tons freshwater saved, hectares of forest saved/created
- **Abatement Costs**
  - Abatement costs = Incremental Costs / Incremental environmental impact

Dynamics and Sensitivities

- **Learning Curves**
  - Is the cost per kWh going down as cumulative production goes up?
- **Sensitivity Analysis**
  - Incorporate uncertainty and future assumptions
  - CEA should contain sensitivity analysis to identify most relevant factors influencing cost effectiveness



- Take key metrics and evaluate a change of += 33% of the metrics on NPV or abatement cost.

Uncertainty and Framing - Oskar

- Five type of uncertainties: Randomness, Indeterminacy, Reductionism, Paradigmatic uncertainty and Unknowable relations

Randomness

- **What is it?**
  - Stochastic behavior
  - We know the range but not the value
  - Get expected values, standard deviations, statistics
- **Example:**
  - Roll a dice, Flip a coin
- **How to deal with it**
  - Sensitivity analysis (Monte Carlo)
  - Estimate from experience
  - Hedging

Indeterminacy

- **What is it? —> No numbers**
  - qualitatively known but not reliably quantified
  - We know X leads to Y but not how much
- **Example:**
  - Weather forecast
- **How to deal with it**
  - Contingent valuation (try to quantify anyway)
  - Heuristics (rule of thumb)
  - Stylized facts

Reductionism (Proxy relationships)

- **What is it? —> Incomplete understanding**
  - X connects to Y, don't know how and what else
  - We can't measure X so we measure Z instead
- **How to deal with it**
  - Lay knowledge (Stories, Narratives, Subjective)
  - Mixed methods (quantitative and qualitative)

Paradigmatic Uncertainty

- **What is it**
  - Perspective Y is not relevant, X is what we do we are experts
  - Narrow perspectives
  - Neglect the unseen
- **How to deal with it**
  - Inderdisciplinarity (co-production of knowledge)
  - Stay curious

Unknowable relations

- **What is it**
  - I have no idea what just happened
  - Unknown unknowns
  - Blak swans
  - Just because you have never seen it doesn't mean it is never going to happen
- **How to deal with it**
  - Humility
  - Adaptation

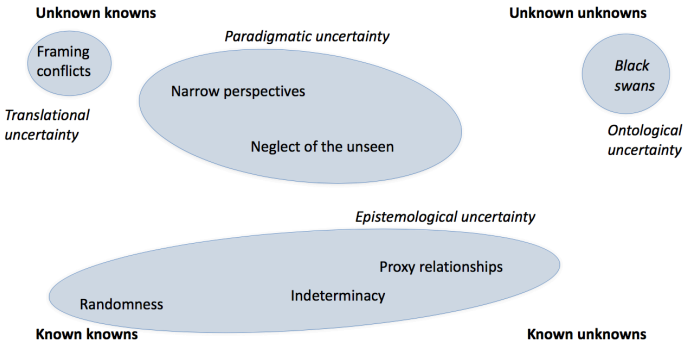
Errors

- **Type 1: False positive**
  - saying a men "you're pregnant"
  - reject null hypothesis when it is true
- **Type 2: False negative**
  - saying a pregnant woman "you are not pregnant)
  - accept null hypothesis when it is wrong
- **Type 3: Ill defined problem**
  - having the correct answer to the wrong question
  - Means you are using the wrong method
  - Hard to avoid when you are deeply in the discipline
  - Example: Rat experiment for heroin

<table>
<tr><th></th><th>Uncertainties</th><th>Analyse with</th><th>Likely errors</th></tr>
<tr><td>Context (exogenous)</td><td>Will model apply to my situation or scenario?</td><td>Scenarios / pathways</td><td rowspan="2">Type 3 errors</td></tr>
<tr><td>Model design</td><td>What questions can the model answer (paradigmatic)?</td><td rowspan="2">Model comparisons</td></tr>
<tr><td>Model implementation</td><td rowspan="2">Correctness (reductionism)</td><td rowspan="3">Type 1 or 2 errors</td></tr>
<tr><td>Model data</td><td rowspan="2">Sensitivity analysis</td></tr>
<tr><td>Measurements</td><td>Variability (randomness)</td></tr>
</table>

Framing and Agenda Setting

- Definition of the problem also circumscribes its solution
- Don't suggest a solution in the problem definition
- Cognitive bias, Anchoring



Game Theory - Tony

Cooperative vs Non cooperative games

- Cooperative games are the ones in which Pareto optimum and Nash equilibrium in different cells.
- Example of cooperative games:
  - Common goods, tragedy of the commons
- Examples of non-cooperative games
  - Firm location (firms cant benefit form cooperation —> non-cooperative)
  - Market entry (cooperation only benefits one firm —> non-cooperative)
  - Price matching (cooperation is illegal —> non-cooperative)

Zero-sum vs Non-zero-sum games

- Non zero-sum game: usually cooperative games, like ultimatum game
- Zero-sum game, one winner and one looser, total payoff fixed, only question is the repartition

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Uncertainty Analysis - Tobias

Uncertainty and Risk

- Risk is the outcome of action taken despite given (known and/or unknown) uncertainties
- Risk = probability of event * financial impact
- Integrate it in CEA by replacing variables with random variables

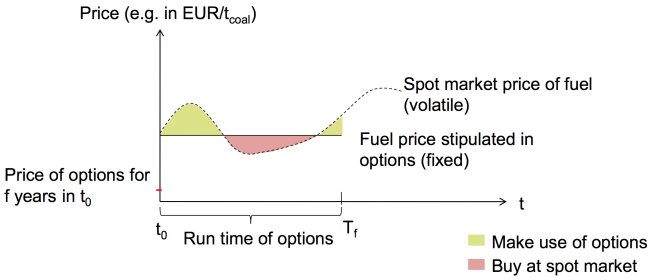
Interpreting Value at Risk

- Give standard errors in addition to expected values
- Evaluate on a expected value of NPV vs standard deviation of NPV graph
  - Choice will depend on which kind of investor you are
  - **Risk-averse investor**
    - facing two investments with same expected return, will choose the less risky one
  - **Risk-neutral investor**
    - indifferent to risk, maximizes return
  - **Risk-seeking investor**
    - facing two investments with same expected return, will choose the most risky one

Hedging Risk with options

- **Call option**

    - right to purchase a commodity at a certain price
- **Put option**
    - right to sell a commodity at a certain price
- Possible to hedge risk by purchasing options, correlated negatively with your other projects.



Risk Analysis - Oskar

Risk Theory

- **Aleatory Risk**
    - Unpredictable, stochastic events that cause harm
    - Risk = Probability * Vulnerability * Damage
    - Vulnerability: depends on containment and Geography
- **Fault Trees**
    - Risk usually comes from compound failures
    - Build a fault tree in order to see where the critical elements are
- **Human Error**
    - When people try to respond to problem but make it worse
    - Can be mitigated through Training, Procedures and Documentation
- **Generalized Peter Principle**
    - “Anything that works will be used in progressively more challenging applications until it fails“
- **Risk Vulnerability**
    - How exposed you are to a problem
    - Can be mitigated through:
        - Spacial separation
        - protective measures
        - Escape plans and measures
    - Depends often on resources —> Small groups sacrificed over large groups
- **Risk Damage**
    - Problem: Data Scarcity
        - Experiments are unethical, mainly data from simulations
        - Generally done by insurers and reinsurers
- **Individual Risk**
    - Chance of death of an individual
- **Societal Risk**
    - number of people suffering harm
    - Long tail is important
- **Risk Resilience**
    - Start managing risk long before the problem happen
    - **Prevent**:
        - Minimize chances of real problems
        - Fix what is broken (even if costs time and money)
        - Establish procedures, training, documentation, checklists
        - Backup equipment on site
    - **Respond**:
        - Get problem diagnosed and under control
        - Monitoring and Alarms
        - Pre established Response plans
    - **Restore**:
        - Get things fixed temporarily
    - **Rebuild**
        - Make things better than they were
        - Make better plans for next problem

Data Quality and Errors - Oskar

Error Propagation

- sum of error of variables != sum of variables's errors
- If fully covariant or independent, different formula.

If $A + B = C$
then $\sigma_A + \sigma_B = \sigma_C$ (if variables are fully covariant)
then $\sigma_A^2 + \sigma_B^2 = \sigma_C^2$ (if variables are fully independent)

Statistical Analysis

- Use carefully, Garbage in —> Garbage out

Long Tail

- Most distributions in risk analysis are interpreted as Bell curves when they actually follow a power law —> Long tail problem as for extreme X the power law has higher probability than gaussian probability distribution.

Bad Data

- For example caused by NDAs. (confidential data)
- Hidden caveats
- Change of collecting method
- Mismatches between datasets.

Generating Alternatives - Tony

Things Governments do

- Taxes
- Regulations
- Subsidies and grants
- Provide services
- Provide information
- Give rights/permissions
- Structure Markets
- Public Education
- Financing and Contracting (infrastructure)

Three Step Process

- Model the system you want to analyze, understand what processes are at work and what policies might influence those processes
- Conceptualize some different approaches, options to reach goal.
- Develop a few detailed Ideas

Optimization Models - Oskar

Energy System

- **Consist of:**
  - Primary Energy Resources (Oil, Gas, Hydro)
  - Conversion Technologies (Power plants, cars)
  - Demand for Energy Services (Heat, Light, Mobility)

Linear Optimisation

- Set of conversions AX = y with constraints
- Finding minimum in an n+1 dimensional space, n capacity variables + cost.
- Advantages:
  - Linear models light and deterministic
  - Easy to manage
- Disadvantages
  - Non-linear systems very hard
  - Problem of local optima in the case of a non-convex system
  - No feedbacks like with system dynamics
- Used to optimize one quantity at the time (cost, time, profit utility)
- Can be static (one point in time) or dynamic (succession of static models, feedback and learning possible)

Multi-Criteria Decision Analysis - Evelina

Goals of MCDA

- Assess several Policy Alternatives
- Acknowledge existence of multiple criteria that cannot be evaluated using the same units
- Combine priorities of policy-makers, stakeholders and the public

Criteria

- **Choosing Criteria**
  - **Value-focused thinking**
    - Elicit overall objectives of relevant actors
    - Translate these objectives into **measurable** criteria
  - **Alternatives-focused thinking**
    - Define criteria by thinking through strength and weaknesses of different alternatives
- **Requirements for Criteria**
  - Value relevance —> are they goals of the decision makers?
  - Understandability
  - Measurability
  - Non-redundancy
  - Judgmental independence —> criteria should be independent
  - Balancing completeness and conciseness —> complete list but not longer than necessary
  - Operationality —> usable within reasonable effort
- **Evaluate Criteria**
  - for all criteria for each policy evaluation
  - Convert criteria performance into value units and normalize them (0=worst, 1=best)
- **Eliciting Weights for aggregating criteria into one index**
  - Individual
    - Ask to rank importance of criteria one by one
    - Pairwise comparison
  - Group
    - Silent negotiations, put one card up at each round
- **Aggregate Criteria into Index**
  - Weighted sum for each policy alternative
  - Or Multi-Attribute Value Theory (MAVT)
  - Assumption: additive functions and compensation

Expert Elicitation - Evelina

Goals of Expert Elicitation

- Collect quantitative evidence using judgment of experts
- Help decision makers under deep uncertainties and lack of other evidence
- Complement (not replace) other types of evidence
- Basically when you have no model, give data to the expert and get an estimation and confidence interval from him. The expert is the model.

Application Examples

- Natural or Environmental Phemonena

- Characteristics of future technologies
- New or poorly understood risks

Why Experts suck

- **Availability bias**
  - Some happened recently/close to here, overestimate the probabilities of it happening again
  - Reducing: before elicitation help experts recall the evidence
- **Qualitative vs Quantitative Estimates**
  - Some experts not comfortable with giving probabilities, give qualitative words like “likely“
- **Overconfidence bias**
  - Reducing bias:
    - Ask about speed of light, and confidence level. Confront it afterwards.
- **Anchoring and Adjustment bias**
  - Reducing bias:
    - let experts choose their own scale, don’t put scale on axis
    - Start by eliciting upper and lower bounds
    - “Can you imagine higher/lower ?“

What you should pay attention to

- Ask only questions for which there are some empirical evidence
- Cut problem into tangible pieces
- Tell the experts about the biases at the start of the interview

Use and abuse of expert elicitation in support of decision making for public policy - Reading

- Are there any experts?
  - When there are no empirical data or no validated model don’t ask experts
  - If there is data available there are experts
- Interpretation of probability
  - Subjective probability should converge to classical probability
  - Careful with anchoring, ask first about extremes
- Avoid overconfidence
  - If enough questions asked to expert, plot calibration curve —> translation from probabilities given by expert and probabilities in the real world
- Drop experts whose calibration score is lower than a cutoff
- If many experts have very different evaluations don’t combine their answers
- Danger:
  - some may find expert elicitation as simple low cost low effort alternative to serious research

---

Cost Benefit Analysis - Evelina

Goals of Expert Elicitation

- Assess value of a project compared to BAU
- Take the societal perspective instead of firm perspective
- Monetize direct / indirect / external costs and benefits

Main Idea

- Exactly like CEA except change in perspective

- use social discount rate
- compare benefits to society with costs to society
- consider secondary markets
- consider non-market impacts (for ex. better health conditions)

Evaluating indirect / external costs and benefits

- Some values are hard to quantify, to give a monetary value
- **Market price**
  - Estimate value of a national park by entrance fee and number of visitors
- **Hedonic pricing/wage**
  - Inconvenience due to traffic noise could be evaluated with housing price difference close and away from the traffic
  - Health risk could be monetized based on wage of persons with and without this health risk
- **Travel cost**
  - Evaluate value of recreational facility based on travel costs for accessing it
- **Averting/defensive behavior**
  - Averting: value of noise estimated by cost of installing double glazed windows
  - Defensive: injury risk monetized by cost of protection equipment (helmets for ex.)
- **Cost of illness / Loss of output**
  - Monetize health costs with costs for treatment + loss of output due to loss of working time
- **Contingent valuation**
  - Evaluate WTP in a survey
  - Evaluate Willingness to accept compensation (WTA) in survey
- **Choice models**
  - Survey

Shadow Prices, Wages and Social discount rate

- **Shadow Price**
  - social opportunity cost of a good or service
  - market price without taxation
  - Use price at country border
- **Shadow Wage**
  - social opportunity cost of labor
  - convert wages to shadow wages with conversion factor
- **Social Discount Rate**
  - indicates social view how future costs and benefits.
  - usually lower than private discount rate
  - **Social Rate of Return on private Investments (SRRI)**
    - Assume social = private discount rate.
  - **Social Rate of Time Preference (SRTP)**
    - rate at which society is ready to postpone a unit of current consumption to the future.

Cost Effectiveness Analysis	Cost-Benefit Analysis
Private perspective, e.g. investor	Social perspective, i.e. society as a whole
Direct costs in market prices	Costs to society as a whole: • Direct costs • Indirect and external costs, i.e. in secondary markets or of non-market impacts
Direct revenues in market prices	Benefits to society as a whole: • Direct benefits • Indirect and external benefits, i.e. in secondary markets or of non-market impacts
Market prices and observed wages	Shadow prices and shadow wages
Private discount rate	Social discount rate
• Financial NPV • Financial payback period • Financial IRR	• Economic NPV that is equal to B-C • Ratios like B/C or (B-C)/C • Economic IRR

The value of the world's ecosystem services and natural capital - Reading

- Ecosystem often given too little weight in policy decisions
- CBA to evaluate the value of the ecosystem
- The estimate represents a minimum value
- Ecosystem services and functions comprise (climate regulation, water supply, refuge, food production etc)
- Valuation based on WTP
- Source of errors: Analysis leaves out many categories of services, ill-information of people when asking for their WTP, majority of services and function outside the market, etc.
- Evaluation to 33*10^12 USD per year.
- Normative argument, ecosystem should be weighted better in Policy decisions

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Scenario Analysis - Evelina

Types of Scenarios

- Predictive: What will happen
  - Forecast: In the most likely case
  - What-if: If that happens
- Explorative: What can happen
  - External: if something external changes
  - Strategic: if we act in a specific way
- Normative: How can a target be reached
  - Preserving: by adjustment in the current situation
  - Transforming: by significantly transforming the current situation
- Hybrid: Combine

Some Scenario Techniques

- **Storylines**
  - Philippe-like bullshitting
- **Model-based**
  - Model as possible future
- **Story-And-Simulation**
  - Mix of the two above
- **Scenario axes**
  - If all combination of drivers A and B are possible. If not —> Cross impact Balance
- **Cross Impact Balance**
  - Internally consistent scenarios are those for which the consistency scores are positive

Scenario Development Processes

- Desk Research
- Participatory
- Hybrid

  - Each driver affects other drivers positively or negatively —> Construct a Cross impact Matrix with expert elicitation
- **Maximally-diverse scenario sets**
  - Take internally consistent scenarios
  - Choose the one with the highest consistency score
  - Select the second one with the maximum squared euclidian distance
  - Select next ones with the maximum harmonic mean of squared distance (from the previously chosen scenarios)

Portfolio Theory - Tobias

Variable Discount Rate

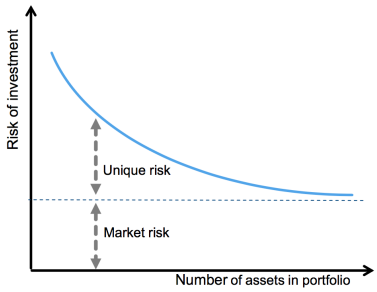
Δ(Risk Premium) = Financing cost at final risk – Financing cost at initial risk

- Cost of capital = Risk-free rate + Risk premium
- Expected changes in investment environment over time can be taken into account by variations of the cost of capital
- Risk goes up, cost of capital goes up
- Rule of thumb: Magic Table
  - Values from literature: Risk premium given Probability of lower CF vs Size of CF reduction
- Changing Cost of capital can only be used with NPV, PI and LCOE —> not IRR

Real Options

- How to mitigate your risk?
- Real options are not like financial options, it is a **method** not a contract.
- Three main types Real options
  - **Option to wait:**
    - Valuation of possibility to take investment later and learn more in mean time
    - like financial call option
  - **Option for follow-on investment:**
    - Valuation of present investment which may entail another investment opportunity
    - like financial put option
  - **Option to abandon:**
    - Valuation of possibility to abandon project if not as profitable as desired
    - like financial put option
- Assign probability to a follow-on investment opportunity. The total NPV of the project (with the option) will be:
  - NPV project + Probability for follow on investment opportunity * NPV follow on investment

Portfolios, managing risk by spreading it



- Risk defined as variance or SD of returns (often assessed with historic data)
- Investment diversification:
  - Risk specific to specific asset can be hedged
- Market risks can not be addressed
- You can never undercut the market risk
- **Portfolio Return**
  - R = sum x_i r_i
  - x_i = investment share of asset i, r_i = return of asset i
- **Portfolio Risk**
  - V(R) = sum_i sum_j xi xj sigma_ij
- **Efficient frontier:**
  - For a two-assets portfolio with different risk, it is the “allowed“ shares of each asset in the portfolio in order to have the highest return for the same risk

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Communication - Tony

Cash et al. Model

- It is the job of communicators to make sure that their message is salient, credible and legitimate

Heath brother’s book:

Success is: **S**imple **U**nexpected **C**oncrete **C**redible **E**motional **S**torie**S**

Tony’s advice

- Make your talk emotional
  - have it reflect your passion
  - fill it with good stories
  - practice for a relaxed authentic delivery
- Make it novel
  - Help audience understand your message is new
  - Give audience something to smile/laugh about
- Make it memorable
  - Keep it short with tree main points
  - be honest

CRED Sabine Marx model

- Know your audience. Their mental models and preexisting beliefs, people absorb information better when it confirms their world view
- Get your audience's attention: frame the problem in a manner that fits their unmet goals
- Translate scientific data into concrete experience
- Don't overuse emotional appeals
- Address scientific and climate uncertainties
- Tap into social identities
- Encourage group participation

Computable General Equilibrium - Tony

Main Idea

- Look at the whole economy
- Can generate useful results in terms of short-term effects of small policy interventions
- **Construct Social Accounting Matrix (SAM)**
  - Many industry sectors (textile, energy, agriculture, banking,…)
  - Many endowments (labour, capital, raw material)
  - Demands on the economy (consumption, savings, investments, exports)
  - In column: where each sector spends its money
  - In line: where each sector makes money
  - SAM is basically a **balance sheet for the whole economy**, can read GDP, Consumption, Investment, Net Exports on it.
- Gather Data on production functions
- Gather Data on Consumer preferences
- Choose value to maximized and run the CGE

What CGE can tell us

- Changes in GDP
- Changes in Productivity of Labor and Capital
- Input, Output and Relative Prices
- All of that at a hypothetical moment in time where the economy is at equilibrium (No Growth)

Problems

- The hypothetical moment in time is pure fantasy
- Any significant policy will have endogenous effects on technology —> Disturbs equilibrium
- No way of knowing if answers from CGE have ever been right and if they have been we don't know why

- Simple answers to complicated problems
- Should not be used as forecasting model, but as thought experiment
- Too complex to understand (at least for poor old Tony)

Path Dependency - Tobias

Path-dependency and Lock-in

- In the case of increasing returns to scale
- Technology with positive feedback result in increasing deployment of the technology
- Set of historical events determine final outcome of technology allocation
- Potential **Lock-in**
  - Lock in is persistent state where sector trapped into a specific technology.
  - Alternative technologies are locked-out.
  - Advantage:
    - can lead to (short term) efficiency
  - Disadvantages:
    - Low learning rates —> long term inefficiency
    - no competition —> no innovation
    - Low diverse systems less resilient to shocks (more fragility towards risk)
- **Factors leading to technological lock-in**
  - Large fixed costs (sunk cost) —> high replacement costs
  - Network effects —> availability of infrastructure make goods more attractive (whatsapp)
  - Technological learning —> Learning curve, learning by using
  - Shared expectations —> using technologies shapes our norms (QWERTY)
- We don’t know ex-ante what the learning curves are going to be

Considering path-dependency in models

- Case: Two firms with substitutable technology, market share after some time depends on the returns to scale of the technology.
- Decreasing returns to scale lead to equilibrium (both firms 50%)
- Constant returns to scale lead to anything (any combination possible)
- Increasing returns to scale lead to lock ins (one firm 100% other 0%)