Eidgenössische Technische Hochschule Zürich
Swiss Federal Institute of Technology Zurich

Climate Change Uncertainty and Risk: from Probabilistic Forecasts to Economics of Climate Adaptation

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Schedule

29.02.16 (1) Logistics, Introduction to probability, uncertainty and risk management, introduction of toy model (RK, DB)

07.03.16 (2) Predictability of weather and climate, seasonal prediction, seamless prediction (RK)
Exercise 1 (toy model)

14.03.16 (3) Detection/attribution, forced changes, natural variability, signal/noise, ensembles (RK)
Exercise 2 (toy model)

21.03.16 (4) Probabilistic risk assessment model: from concept to concrete application - and some insurance basics (DB)

28.03.16 Ostermontag (no course)

04.04.16 (5) Model evaluation, multi model ensembles and structural error (RK)

11.04.16 (6) Climate change and impacts, scenarios, use of scenarios, scenario uncertainty vs response/impact uncertainty (RK, DB)
Exercise 3 (toy model), preparation of presentation

18.04.16 (7) Model calibration, Bayesian methods for probabilistic projections (RK)

25.04.16 (8) Presentations of toy model work, discussion (DB, RK)

Schedule

02.05.16 (9) Basics of economic evaluation and economic decision making in the presence of climate risk (DB)
Exercise 4 (introduction to climada)
09.05.16 (10) The cost of adaptation - application of economic decision making to climate adaptation in developing and developed region (DB)
Exercise 5 (impacts)
16.05.16 Pfingstmontag (no course)
23.05.16 (11) Shaping climate-resilient development – valuation of a basket of adaptation options (DB)
Exercises 6 (adaptation measures, preparation of presentation)
30.05.16 (12) Presentations of climada exercise, discussion (DB, RK)

Today's agenda

- Discounting basics
- Costs and benefits
- (Note on markets)
- Discount rate
- Time preference
- The price of human life – and the price of health and wellbeing
- The (im)morality of discounting

present slides do contain the results of the online survey

Economic versus climate models

- In what sense (or simply: How) are economic models different from climate models?

Discounting – basics (1/3)

- All consideration are net of inflation, means all future costs and benefits expressed in terms of the amount they could purchase at today's prices. If we expect 3% inflation next year, then $103 at next year's prices has the same purchasing power as $100 at today's prices. So we can refer to it as $100 in 'real' or inflation-adjusted dollars (or any other currency).
- Is it better to receive $100 today or to receive $100 in the future?
→ clearly better to receive $100 today and to put it into a bank account. At say 2% interest, you will possess $122 [=100*$(1+0.02)^{10}$] in ten years from now. Or you only need to put $82 into the bank today to receive $100 in ten years [=100/$(1+0.02)^{10}$]. In the jargon of economics, $82 today is the <u>present value</u> of 100$ to be received ten years from now, at a <u>discount rate</u> of 2%.
- The present value is the amount you would have to put in a bank account today, earning interest at discount rate, to end up with the target amount at the specified time in the future.

Discounting – present value (2/3)

- All compound interest and discounting examples in this course are based on <u>annual compounding calculations</u>. Compounding over different time periods or continuous-time calculations as in formal economic theory, produce different numbers, but support the same qualitative conclusions.
- Formally speaking: *FV* denotes the future value, *PV* the present value, *n* years at interest *i*:

$$FV = PV(1+i)^n \qquad PV = \frac{FV}{(1+i)^n}$$

- and hence:

$$i = \left(\frac{FV}{PV}\right)^{\frac{1}{n}} - 1 \qquad n = \frac{\log(FV) - \log(PV)}{\log(1+i)}$$

see e.g. http://en.wikipedia.org/wiki/Compound_interest

Discounting – continuous compounding (3/3)

- With *A(t)* denoting the initial amount A_0 after time *t* at annual interest *r* compounded *n* times per year (for *n*=1: same as before):

$$A(t) = A_0 \left(1 + \frac{r}{n}\right)^{nt}$$

- continuous compounding can be thought as making the compounding period infinitesimally small; therefore achieved by taking the limit of *n* to infinity (see definition of the exponential function for the mathematical proof of this limit):

$$a(t) = \lim_{n\to\infty} \left(1 + \frac{r}{n}\right)^{nt}$$

$$a(t) = e^{rt}$$

- and therefore $A(t)=A_o e^{rt}$ with the link to the effective interested rate (used in this course) as $i=e^r-1$, difference for $r<5\%$ smaller than errors in assumption of *r* (e.g. $r=10.00\%$, $i=10.52\%$)

see e.g. http://en.wikipedia.org/wiki/Compound_interest

Economics survey – thanks for participation!

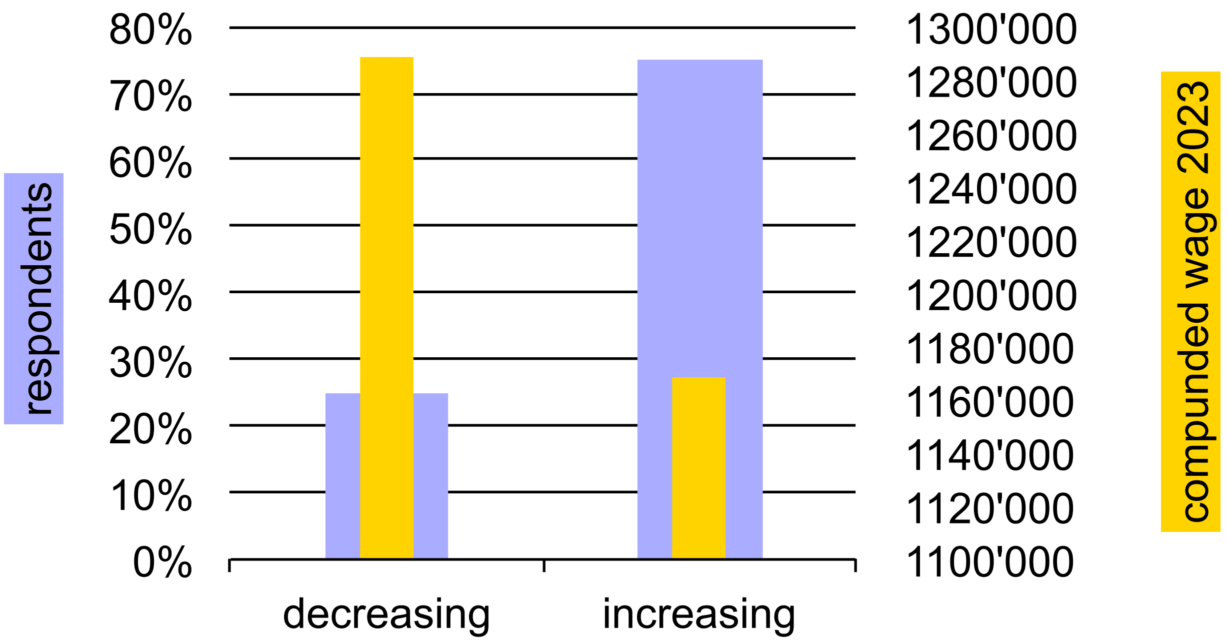
https://services.iac.ethz.ch/survey/index.php/239445/lang-en

A few questions to gather some data iro time preference etc.
Took about 2 min.

→ 12 respondents by Sun 1 May 2016 at noon

Wage pattern

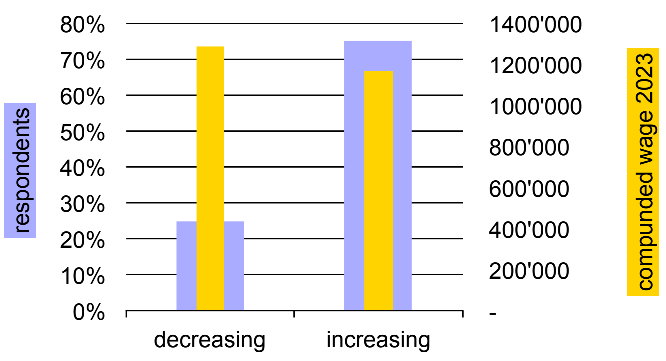
Question 1: Which wage pattern would you prefer for a job lasting 10 years - increasing or decreasing wages? (50’000, 55’000…, or 100’000, 95’000….)



→ The majority does not intuitively compound

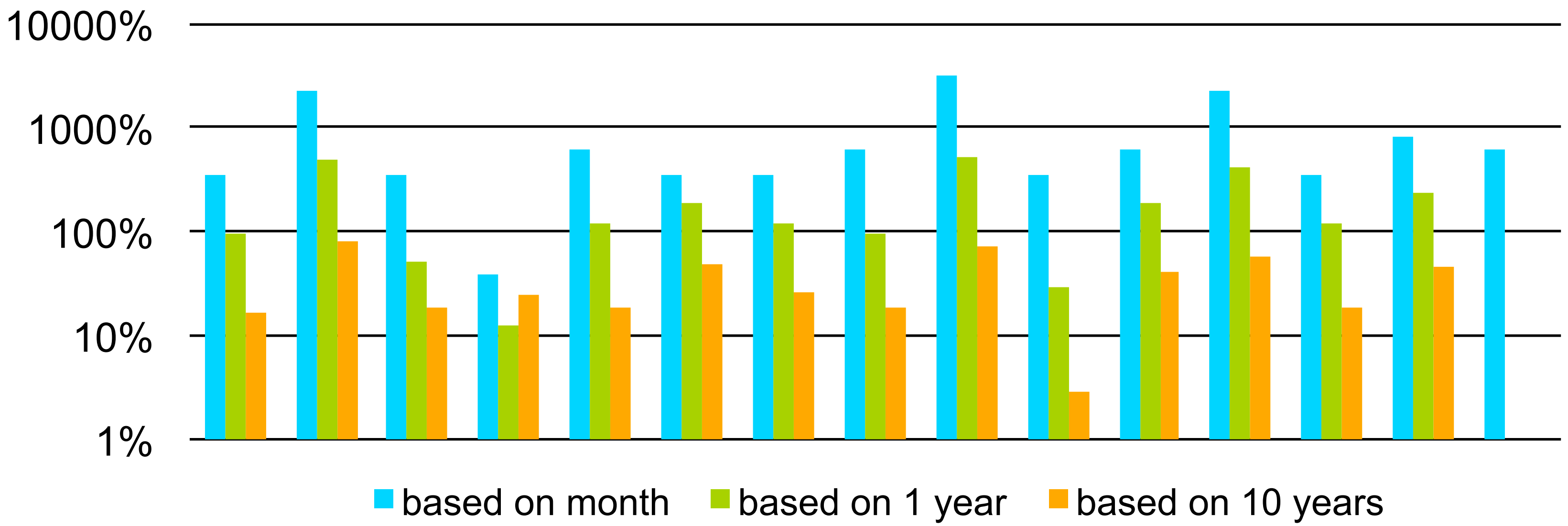
Wage pattern – comments

- Decreasing: Simply allows for more return on investment. Or: Life is uncertain, eat dessert first. Plus: interest rate gives me more money at the end.
- One might argue that what you already received no one can take it away again (in case of an insolvency). And secondly, assuming some interest on the received money, the first option is also better.
- Increasing: It is harder to adapt to less money than to more money.
- Increasing: Can't get used to lower wages once I've seen the big money.
- With the increasing experience in the job, the salary should increase in time. Prices will rise, I don't want to earn less as I become more valuable to the company!
- Rationally it would probably be more beneficial to get more money at the beginning of a career, but on the other hand it would be highly demotivating to get less and less money in the future.
- Clever: Up to now, I wanted to have a constant increase in the earnings but when I think honestly, I would prefer more time to more money. Therefore, the decrease would be due to the reduction in working time.



Compounding (1/2)

Question 2: Instead of receiving 15.- today, what amount would you expect to be paid in order to wait 1 month, 1 year or 10 years before receiving your money? Raw data (max after 1 month: 200, after 10 years: 50’000 !!!), leading to interest rates of:



Compounding (2/2)

Question 2: Instead of receiving 15.- today, what amount would you expect to be paid in order to wait 1 month, 1 year or 10 years before receiving your money? Answer after some filtering:

→ **average 10-year discount rate 17%** (unfiltered even 36% !!!)

Note: Survey done since 2010, never so high an expectation (max so far 15%, unfiltered 29%).

Discounting – note on usury (“Wucher”)

- Usury (from the Medieval Latin usuria, "interest" or from the Latin usura "interest") originally meant the charging of interest on loans. This included charging a fee for the use of money. After interest became acceptable, usury came to mean the interest above the rate allowed by law. In common usage today, the word means the charging of unreasonable or relatively high rates of interest.
- The First Council of Nicaea in 325, forbade clergy from engaging in usury. At the time "usury" simply mean interest of any kind, and the canon merely forbade the clergy to lend money on interest above one per cent per month (11.57% annual). Later ecumenical councils applied this regulation to the laity.
- Lateran III decreed that persons who accepted interest on loans could receive neither the sacraments nor Christian burial. Pope Clement V made the belief in the right to usury a heresy in 1311, and abolished all secular legislation which allowed it. Pope Sixtus V condemned the practice of charging interest as "detestable to God and man, damned by the sacred canons and contrary to Christian charity."

Source: http://en.wikipedia.org/wiki/Usury

Costs and benefits (1/5)

- Net present value calculations are used to compare amounts paid (costs) and received (benefits) in different years.
- A project is economically viable (attractive), if the net present value of benefits exceeds the net present value of costs, or cost-benefit ratio <1
- E.g. an investment of $100 in 2016, leading to a benefit of $123 in ten years time is perceived as attractive (cost-benefit ratio <1) if an interest rate of 2% is assumed (PV of $123 at 2% equals $101). Note that this is only true if you have no other option to invest at a better rate than 2% - and obviously crucially dependent on the assumption about the interest rate.
- In most cases, one deals with cost and benefit streams or patterns over years. Hence one needs to discount (complex) payment patterns – and often with a time-dependent yield curve (the key reason for the success of Excel)

Costs and benefits – example 1 (2/5)

A simple example shall illustrate this:

- Let’s assume we expect a climate-related loss of 20 mio CHF by 2026 and hence evaluate the option to invest in prevention (the cost) starting 2016 in order to avert the loss (the *benefit*).
- Let’s further assume the preventive measure be a dam to be built in 2016 (at a *cost* of 10 mio CHF) and recurring maintenance costs of 1 mio CHF every second year.
- Is it worth building the dam?
- No discounting, cost: dam, benefit: averted loss, in mio CHF:

interest	0%	year										
	NPV	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
cost	15	10		1		1		1		1		1
benefit	20											20
cost/benefit	0.75											

Costs and benefits – example 2 (3/5)

- at 2% discount rate:

interest	2%	year										
	NPV	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
cost	14.45	10		1		1		1		1		1
benefit	16.41											20
cost/benefit	0.88											

$$\text{cost}=10+\underbrace{0/(1+2\%)}_{2017}+\underbrace{1/(1+2\%)^2}_{2018}+\underbrace{0/(1+2\%)^3}_{2019}+\underbrace{1/(1+2\%)^4}_{2020}\ldots$$

→ see exercise

- at 5% discount rate:

interest	5%	year										
	NPV	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
cost	13.77	10		1		1		1		1		1
benefit	12.28											20
cost/benefit	1.12											

Discounting – Matlab hints

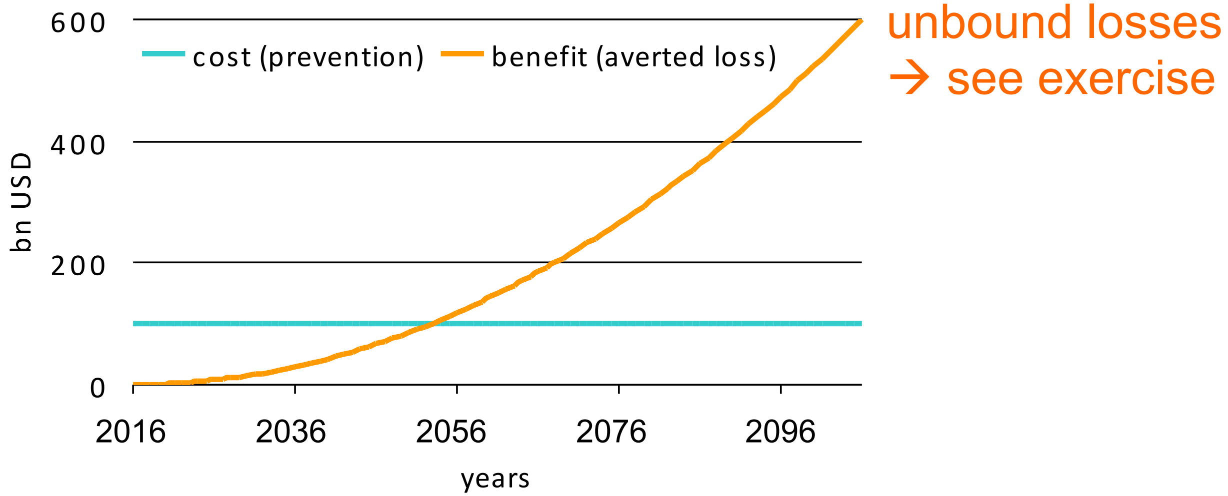
The routine climada_NPV provides the discounting

- The discount rate is defined in the entity.discount (imported from the discount tab of the Excel sheet), the different fields are:
  - `year:` the reference year for the rate
  - `discount_rate:` the discount rate for a given year
  - `yield_ID:` to accommodate different rate tables, not implemented yet
- In climada_NPV, the discount rate for each year is looked up and applied to the yearly series of payments.
- The global variables `climada_global.present_reference_year` (currently set to 2016) and `climada_global.future_reference_year` (currently set to 2030) define the reference dates for discounting (basically the position of the present and future time slices).

→ see climada_NPV.m

Costs and benefits – climate policy example (4/5)

The benefits of climate policy (averted loss) start out small but grow faster and faster over time, while costs begin immediately but do not rise as rapidly, if at all (illustrative example):

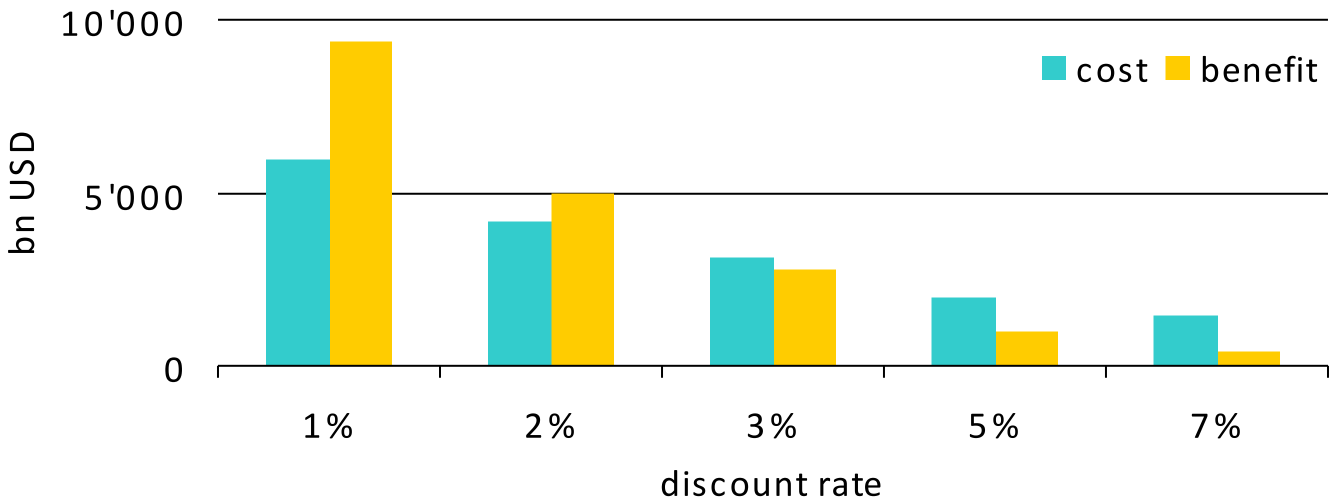


Costs exceed benefits for the first 40 years, but benefits (averted losses) rise rapidly thereafter. In 60 years time, losses are already twice as big as prevention costs. Do the cumulative benefits (averted losses) exceed cumulative costs?

Source: F. Ackerman, 2009: Can we afford the future, ZED book, New York

Costs and benefits – climate policy example (5/5)

The balance between costs and benefits depends entirely on the discount rate. The policy (to finance prevention) is a bargain at a 1% discount rate, the present value of 90 years of benefits (averted costs) is about 50% greater than the present value of the corresponding costs.

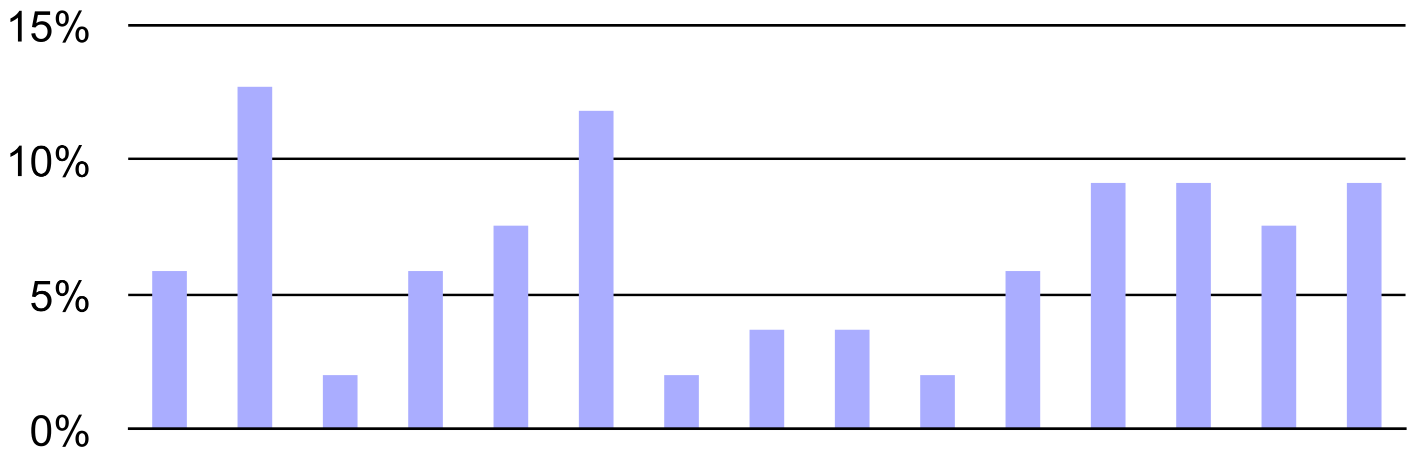


At 3% discount rate, the balance has tipped in the opposite direction, present value of benefits being just a little less than the costs. And at 5%, the policy is not worth implementing, with benefits only half the costs. (but!)

Source: F. Ackerman, 2009: Can we afford the future, ZED book, New York

Investment (1/2) – Prospective gain

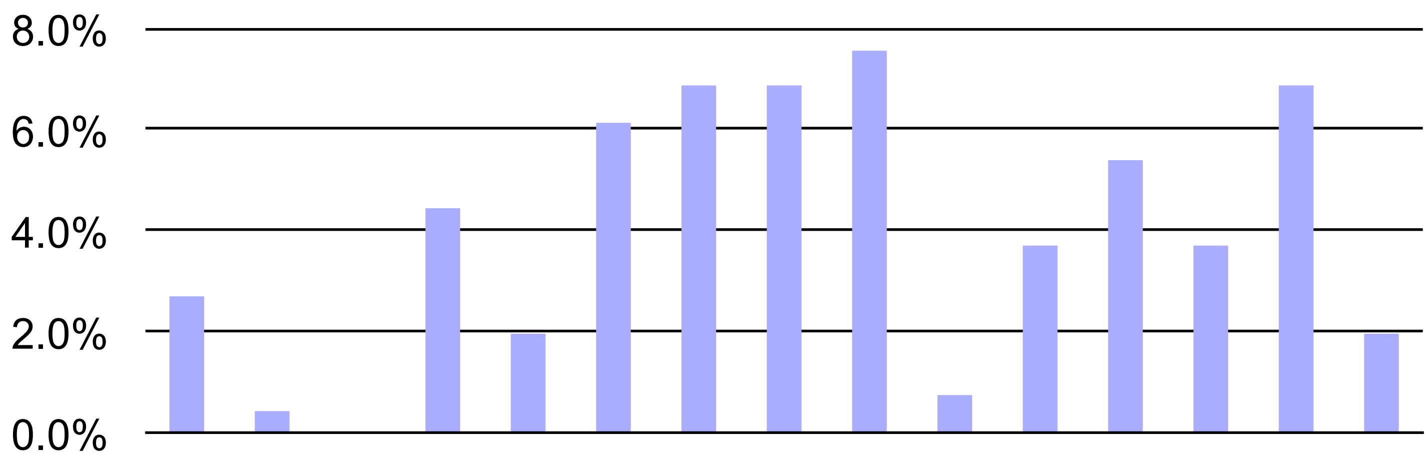
Question 3: What investment are you willing to make today in order to obtain 225.- by 2053? Raw data (min: 1 → 13%, max: 100 → 2%), leading to discount rate:



→ average discount rate 6.5% (based on 40-year time horizon)

Investment (2/2) – Averted loss

Question 4: To avert a loss of \$600 bn in 2102, what amount would you be willing to spend today? (Raw data min[1]: 0.5 → 7.6%, max: 601 → 0%)
Leading to discount rates:



→ **average discount rate[2] 4.2% (based on 90-year time horizon)**

[1]Nobody put in 0 this year, as that would really reflect wishful thinking...
[2]Really the average. In previous years, I had to filter due to some unrealistic responses

Note on markets

- The concept of a market is any structure that allows buyers and sellers to exchange any type of goods, services and information.
- The exchange of goods or services for money is a transaction.
- Market participants consist of all the buyers and sellers of a good who influence its price. This influence is a major study of economics and has given rise to several theories and models concerning the basic market forces of supply and demand.
- There are two roles in markets, buyers and sellers. The market facilitates trade and enables the distribution and allocation of resources in a society.
- <u>Markets allow any tradable item to be evaluated and priced.</u>
- A market emerges more or less spontaneously or is constructed deliberately by human interaction in order to enable the exchange of rights of services and goods.

Source: http://en.wikipedia.org/wiki/Market

Discount rates (1/4)

There exist two broad families of theories about the discount rate:

- Descriptive approach
  - Discount rate should be equal to market interest rate, or the rate of return on financial investments
  - This approach advocates that climate investments should be made on the same basis as any other investments
- Prescriptive approach
  - Builds up the discount rate from first principles, based on two separate motives for discounting:
    - expected upward trend in income and wealth
    - pure time preference
  - This approach is more open to consideration of the complexity of climate investments

Source: F. Ackerman, 2009: Can we afford the future, ZED book, New York

Discount rates – descriptive approach (2/4)

There exist different version of descriptive approaches:

- Based on stock market long-term average return 5-7%
  → for climate policy the game is over before it starts
  (see previous example) – But: the stock market is only one market
- Based on government bonds: In order to achieve rates as high as 5-7%, one has to make risky investments. The rate of return on risk-free investments, such as government bonds, is much lower, averaging 1% or less above the rate of inflation.

Climate protection

- is most valuable (needed) when things turn badly (like insurance), and less in need when things go well, when one can deal with ups and downs of normal (stock-)market risk.
- is a risk-reducing investment, hence <u>the risk-free rate of return is more appropriate, of the order of 1%</u>

Source: F. Ackerman, 2009: Can we afford the future, ZED book, New York

Discount rates – prescriptive approach (3/4)

The prescriptive approach is based on two (separate) motives:

- expected upward trend in income and wealth: If future generations will be much richer then we are, they will need less help from us. So we can discount benefits that will flow to our wealthy descendants, on a rate based on expected growth of per capita incomes.
  - Note: If future generations turned out to be poorer, they would need more help from us, hence discount rate would be less than zero. Economic models and theories, however, almost always assume that incomes will grow – among economists, the income-related motive for discounting may be the least controversial part of the picture.
- pure time preference: the rate that would apply if all generations had the same per capita income. Time preference exists, since:
  - People prefer money now to money later, the psychological argument
  - The human race might not survive for ever. If there is a tiny probability of extinction (Stern's guess: 1‰), there should be a tiny contribution to the rate of pure time preference.

Source: F. Ackerman, 2009: Can we afford the future, ZED book, New York

Discount rates – Stern's approach (4/4)

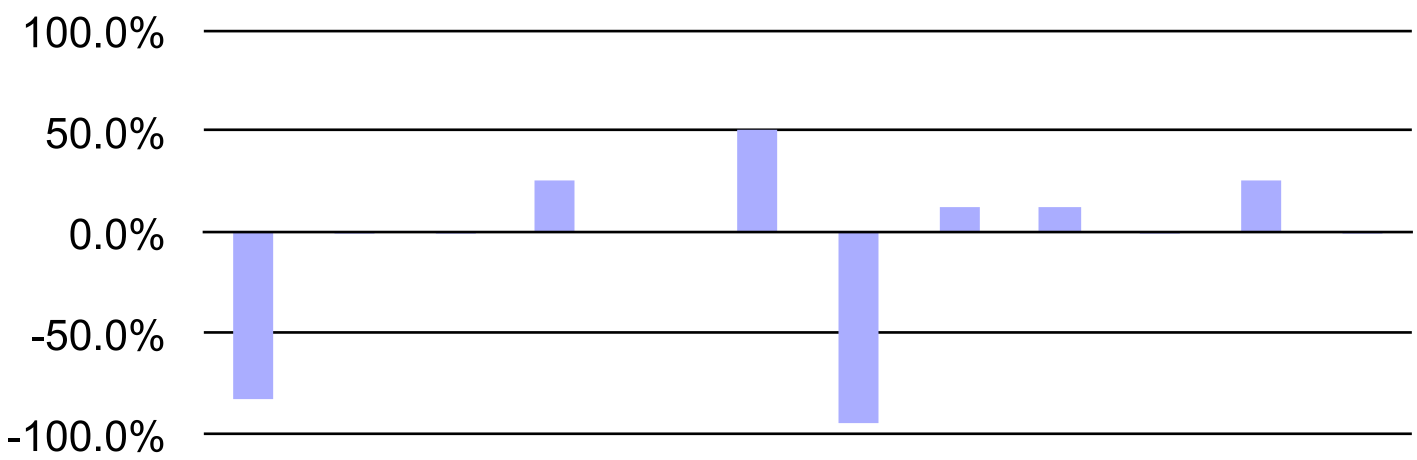
Following the prescriptive approach

- expected upward trend in income and wealth:
  1.3% long-term average growth of per capita income.
- pure time preference:
  - Stern reviewed and endorsed the philosophical arguments for viewing all generations as people of equal worth, deserving equal rights and living conditions. As he states "if you care little about future generations you will care little about climate change. As we have argued that is not a position which has much foundation in ethics".
  - Stern observed that a natural or man-made disaster could destroy the human race. He arbitrarily assumed the probability of such a disaster to be 0.1% per year, and set pure time preference at that rate.
- <u>Stern's discount rate: 1.4%</u> (=1.3%+0.1%)
- Much lower than the rates used in traditional climate economics models

Source: Stern review, 2006

Willingness to get the future now

Question 5: You will receive an iPad <u>in a year from</u> now for $400. What amount would you be **willing to pay to receive it <u>today</u>**? (Raw data min[1]: 0, max: 600 → 50%). Leading to the following discount rates:

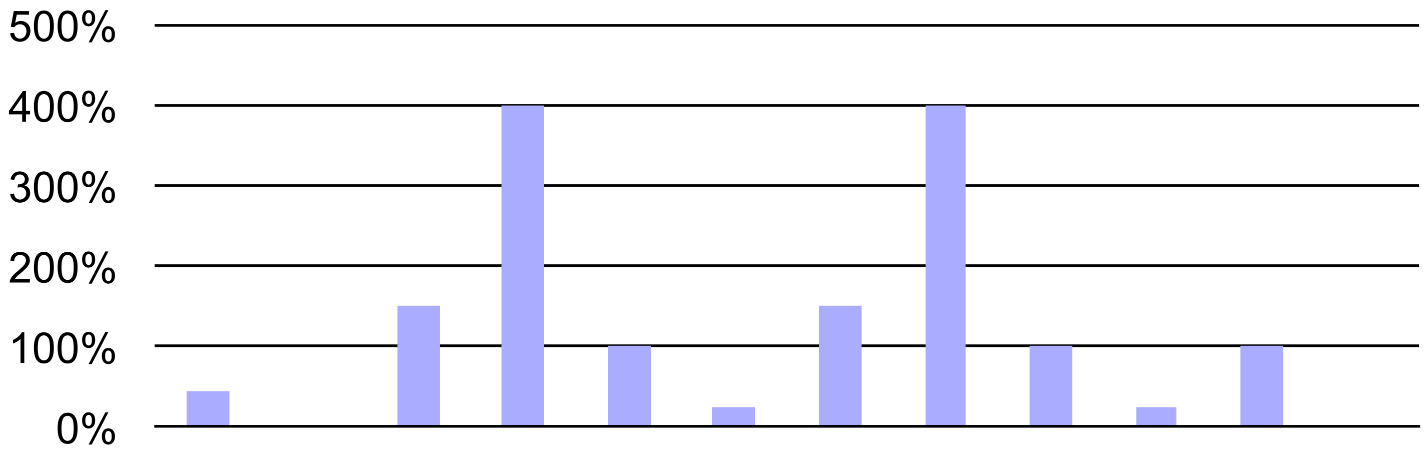


→ average discount rate[2] 25%

[1]Four respondents put in 0, means just they neither need nor aspire to an iPad ☺
[2]Based on amounts > $400 (two put amounts >$0 but <$400 in)

Willingness to wait for the future

Question 6: You get an iPad <u>today</u> for $500. (By) what amount would it's price need to be *reduced* for you **<u>to wait</u>** another year to obtain it? Leading to the following discount rates:

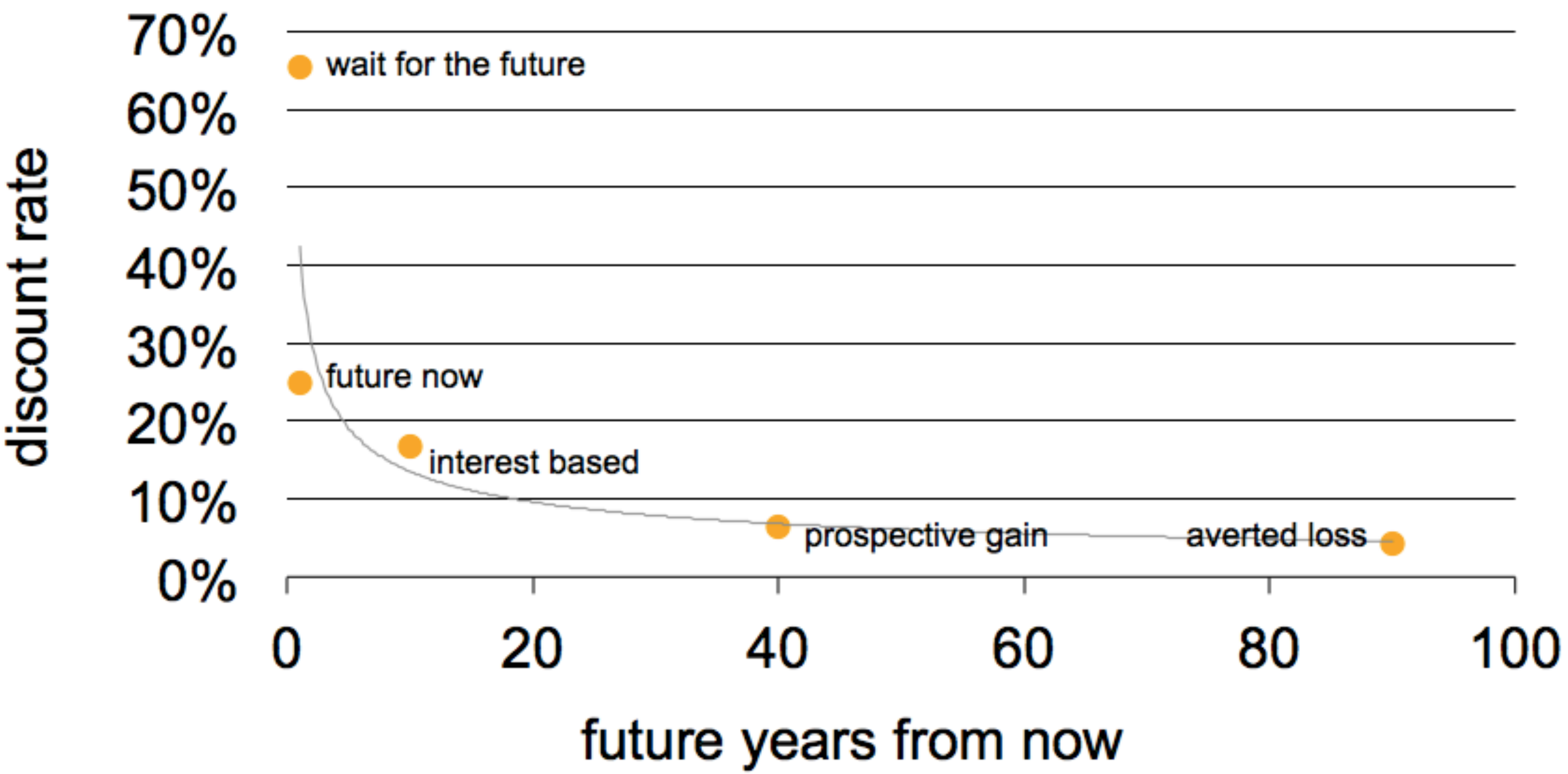


→ **average discount rate**[1] **65%** (raw: 150% as in above graph)

[1]Based on 'reasonable' amounts

Summarizing

There is (kind of) a hyperbolic time-dependency:



Time preference (1/6)

Two perspectives, according to John Rae (1834):

- immediate pleasure of anticipation (anticipatory-utility): deferral of gratification will occur only if it produces an increase in “anticipal” utility that more than compensates for the decrease in immediate consumption utility.
  This perspective attributes variations in intertemporal-choice behavior to differences in people’s abilities to imagine the future and to differences in situations that promote or inhibit such mental images.
- immediate discomfort of self-denial (abstinence): assuming equal treatment of present and future (zero discounting) as the natural baseline for behavior, attributing the overweighting of the present to the miseries produced by the self-denial required to delay gratification: “To abstain from the enjoyment which is in our power, or to seek distant rather than immediate results, are among the most painful exertions of the human will” [N. W. Senior].
  This perspective explains variations in intertemporal choice behavior on the basis of individual and situational differences in the psychological discomfort associated with self-denial.

Source: Rae, J., 1834: The Sociological Theory of Capital. and Frederick, S. et al, 2002: Time Discounting and Time Preference: A Critical Review, Journal of Economic Literature Vol. XL (June 2002), pp. 351–401.

Time preference (2/6)

Another perspective, according to Eugen von Böhm-Bawerk (1889):

- humans suffer from a systematic tendency to underestimate future wants. Böhm-Bawerk began modeling intertemporal choice in the same terms as other economic trade-offs – as a “technical” decision about allocating resources (to oneself) over different points in time, much as one would allocate resources between any two competing interests, such as housing and food.
- formalized by the American economist Irving Fisher (1930): pure time preference can be interpreted as the marginal rate of substitution in time under the assumption of equal consumption.
- and Fischer wrote (1930): “The most fitful of the causes at work [for time preference] is probably fashion. This at the present time acts, on the one hand, to stimulate men to save and become millionaires, and, on the other hand, to stimulate millionaires to live in an ostentatious manner.”

Source: Frederick, S. et al, 2002: Time Discounting and Time Preference: A Critical Review, Journal of Economic Literature Vol. XL (June 2002), pp. 351–401.

Discounted utility model (3/6)

The discounted utility model (Paul Samuelson, 1937):

- to offer a generalized model of intertemporal choice that was applicable to multiple time periods and to make the point that representing intertemporal trade-offs required a cardinal measure of utility:

$$U^t(c_t,\ldots,c_T) = \sum_{k=0}^{T-t} D(k)u(c_{t+k})$$

$$\text{where } D(k) = \left(\frac{1}{1+\rho}\right)^k$$

- $u(c_{t+k})$ a person's instantaneous utility, $c_.$: consumption profiles, k for "time stepping" (e.g. years)
- But: In Samuelson's simplified model, all the psychological concerns discussed over the previous century were compressed into a single parameter, the discount rate ρ. And…

Source: Frederick, S. et al, 2002: Time Discounting and Time Preference: A Critical Review, Journal of Economic Literature Vol. XL (June 2002), pp. 351–401.

Discounted utility model (4/6)

Samuelson did <u>not endorse the discounted utility model as a normative model</u> of intertemporal choice, noting that “any connection between utility as discussed here and any welfare concept is disavowed”. He also made no claims on behalf of its descriptive validity, stressing, “It is completely arbitrary to assume that the individual behaves so as to maximize an integral of the form envisaged in the discounted utility model”.

However, despite Samuelson’s manifest reservations, the <u>simplicity and elegance of this formulation was irresistible</u>, and the discounted utility model was rapidly <u>adopted as the framework of choice</u> for analyzing intertemporal decisions.

More recently, Koopmans (1960), showed that the model could be derived from a superficially plausible set of axioms. He did not argue that the model was psychologically or normatively plausible; his goal was only to show that under some well-specified (though arguably unrealistic) circumstances, individuals were logically compelled to possess positive time preference. Koopmans’ central <u>technical message was largely lost</u> while his axiomatization of the discounted utility model helped to cement its popularity and bolster its <u>*perceived* legitimacy</u>.

Source: Frederick, S. et al, 2002: Time Discounting and Time Preference: A Critical Review, Journal of Economic Literature Vol. XL (June 2002), pp. 351–401.

Discounted utility model (5/6)

Important features of the discounted utility model leading to concerns:

- Integration of new alternatives with existing plans: Prospect X is not evaluated in isolation, but in light of how it changes the person's aggregate consumption in all future periods. Thus, to evaluate the prospect X, the person must choose what her new consumption path ($c'_t,\ldots,c'_T$) would be if she were to accept prospect X. While integration seems normatively compelling, it may be too difficult to actually do. A person may not have well-formed plans about future consumption streams, or be <u>unable (or unwilling) to recompute the new optimal plan every time</u> she makes an intertemporal choice. (→ neglecting complexity)
- Utility independence: The discounted utility model explicitly assumes that the overall value – or "global utility" – of a sequence of outcomes is equal to the (discounted) sum of the utilities in each period. Hence, the distribution of utility across time makes no difference beyond that dictated by discounting, which (assuming positive time preference) penalizes utility that is experienced later. It <u>rules out any kind of preference for patterns of utility over time</u> – e.g., a preference for a flat utility profile over a roller-coaster utility profile with the same discounted utility (→ externalization of price for stability)

Source: Frederick, S. et al, 2002: Time Discounting and Time Preference: A Critical Review, Journal of Economic Literature Vol. XL (June 2002), pp. 351–401.

Discounted utility model (6/6)

concerns (contd.):

- Independence of discounting from consumption: The discounted utility model assumes that the discount function (essentially a single parameter, the discount rate ρ) is invariant across all forms of consumption. This feature is crucial to the notion of time preference. If people discount utility from different sources at different rates, then the notion of a unitary time preference is meaningless. Instead we would need to label time preference according to the object being delayed—"banana time preference," "vacation time preference," and so on: "climate time preference"…
- Furthermore, even for a given delay, discount rates vary across different types of intertemporal choices: gains are discounted more than losses, small amounts more than large amounts, and explicit sequences of multiple outcomes are discounted differently than outcomes considered singly.

→ Climate protection is most valuable (needed) when things turn badly. This is a risk-reducing investment, hence the risk-free rate of return (~1%) is more appropriate, than for a decision in e.g. banana trade (especially since bananas rot).

Source: Frederick, S. et al, 2002: Time Discounting and Time Preference: A Critical Review, Journal of Economic Literature Vol. XL (June 2002), pp. 351–401.

Time preference – a last remark (7/6)

concerns (contd.):

The most compelling argument supporting the logic of positive time preference was made by Derek Parfit (1971; 1976; 1982), who contends that there is no enduring self or "I" over time to which all future utility can be ascribed, and that a diminution in psychological connections gives our descendent future selves the status of other people – making that utility less than fully "ours" and giving us a reason to count it less: "We care less about our further future . . . because we know that less of what we are now – less, say, of our present hopes or plans, loves or ideals – will survive into the further future . . . [if] what matters holds to a lesser degree, it cannot be irrational to care less." Parfit's claims are normative, not descriptive. He is not attempting to explain or predict people's intertemporal choices, but is arguing that conclusions about the rationality of time preference must be grounded in a correct view of personal identity. However, if this is the only compelling normative rationale for time discounting, it would be instructive to test for a positive relation between observed time discounting and changing identity.

Sources:
Parfit, D., 1971: Personal Identity, Philosophical Rev. 80:1, pp. 3–27. and 1982: Personal Identity and Rationality, Synthese 53, pp. 227–41.
Frederick, S. et al, 2002: Time Discounting and Time Preference: A Critical Review, Journal of Economic Literature Vol. XL (June 2002), pp. 351–401.

And a note on time commitment

Perhaps the best empirical demonstration of a preference for commitment was conducted by Dan Ariely and Klaus Wertenbroch (2002). In that study, MIT executive-education students had to write three short papers for a class and were assigned to one of two experimental conditions.

- In one condition, deadlines for the three papers were imposed by the instructor and were evenly spaced across the semester.
- In the other condition, each student was allowed to set her own deadlines for each of the three papers.

In both conditions, the penalty for delay was 1 percent per day late, regardless of whether the deadline was externally or self-imposed. Although students in the free-choice condition could have made all three papers due at the end of the semester, many did, in fact, choose to impose deadlines on themselves, suggesting that they appreciated the value of commitment.

Few students chose evenly spaced deadlines, however, and those who did not performed worse in the course than those with evenly spaced deadlines (whether externally imposed or self-imposed).

Sources: Dan Ariely, 2002: Predictably irrational. The hidden forces that shape our decisions, Harper Collins.

Price tag on human life (1/2)

- If losses of human life are excluded from monetary calculations on the grounds that they have no price, any dollar estimate of climate damages is crucially incomplete.
- If they are to be included, one needs to know the price of a human life:
- Based on wage differentials (e.g. EPA, 1990s): annual risk of death in a (typical blue-collar) job is 1 in 10'000, at a 30 cents/hour (or 600$/year) wage increase compared to workers with 'no' risk of death in job → 1/10'000 of a life 'worth' 600$ → whole life 'worth' 6 mio USD
- Based on willingness to pay (e.g. Bush admin, 2001): People asked to fill long questionnaires to determine what they would pay for a small change in risk under abstract, hypothetical scenarios, say 3.70$ to avoid a one in a million risk of death → whole life 'worth' 3.7 mio USD

Source: F. Ackerman, 2009: Can we afford the future, ZED book, New York

Price tag on human life – BUT! (2/2)

- Note on the switch to willingness to pay: that's why fewer environmental policies were able to pass a cost-benefit test under the Bush administration – but that was not the (stated) purpose of the shift to survey-based values.
- None of such methods comes close to capturing the profound meaning of a preventable human death, or a life saved. Ethical judgements about life and death are not measured by small wage differentials for risky jobs, or by surveys asking a small sample of the population to answer hypothetical questions about minute risks – and then simply scaling up, which implies an awkward assumption about fractionality of 'life'.
- There is no research agenda that can lead to a more meaningful dollar value of a life – the problem is that it is <u>an unreasonable question to be asked in the first place</u>.

→ instead of convoluting loss of life into monetary metrics, one shall <u>quantify loss of life in its own metric</u> – simply the number of casualties

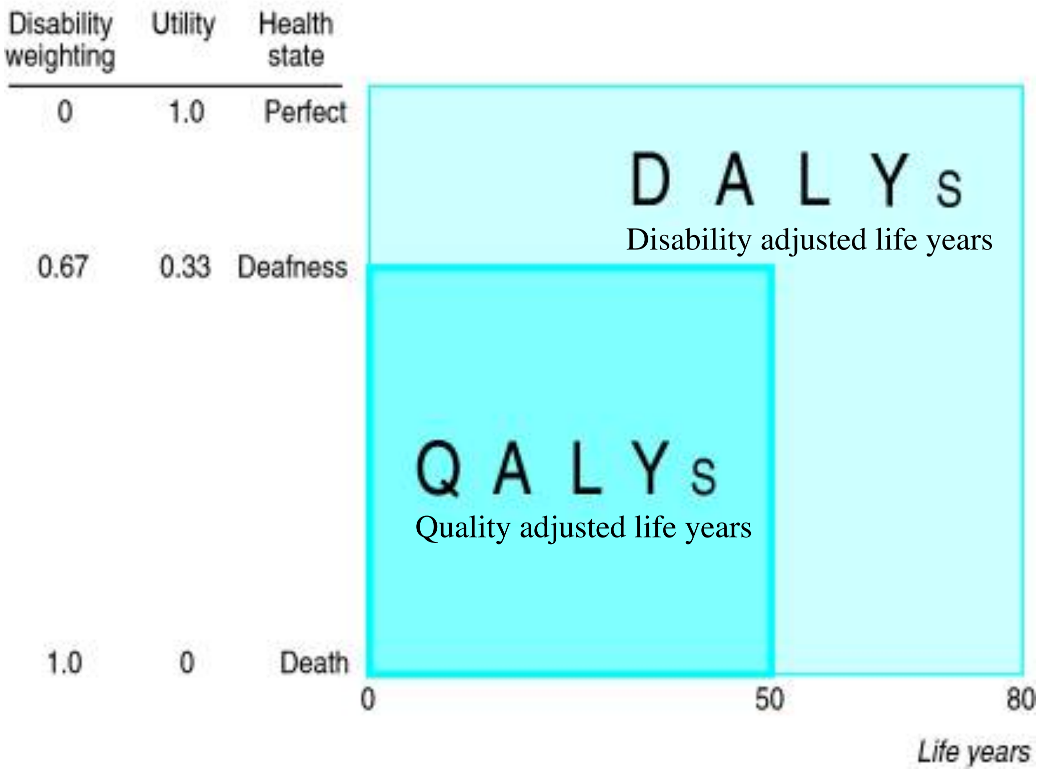
Source: F. Ackerman, 2009: Can we afford the future, ZED book, New York

Quantification of disability or quality of life (1/3)

- Disability adjusted life years (DALYs) have been launched by the World Bank and backed by the World Health Organisation as a measure of the global burden of disease[1,2]. The aim is ambitious: “The burden of disease has yet to entirely replace traditional approaches to the assessment of health needs as an influence on political decision making.”
- Just like quality adjusted life years (QALYs), DALYs combine information about morbidity and mortality in numbers of healthy years lost. In the DALY approach, each state of health is assigned a disability weighting on a scale from zero (perfect health) to one (death) by an expert panel. To calculate the burden of a certain disease, the disability weighting is multiplied by the number of years lived in that health state and is added to the number of years lost due to that disease. Future burdens are discounted at a rate of 3% per year, and the value of the lifetime is weighted so that years of life in childhood and old age are counted less.

Sources:[1]World Bank. World development report 1993: investing in health. New York: Oxford University Press; 1993.
[2]Murray C, Lopez A. The global burden of disease. Cambridge, MA: Harvard University Press; 1996.

Quantification of disability or quality of life (2/3)



DALYs and QALYs are complementary concepts. QALYs are years of healthy life lived; DALYs are years of healthy life lost. Both approaches multiply the number of years (x axis) by the quality of those years (y axis). QALYs use “utility” weights of health states; DALYs use “disability weights” to reflect the burden of the same states.

For example, the disability weight of deafness be 0.67, hence the utility 0.33 (=1-0.67). Disregarding age weighting and discounting, and assuming life expectancy of 80 years, a deaf man living 50 years represents 0.67×50=33.4 QALYs gained and 0.33×50+30×1=46.6 DALYs lost

Source: British Medical Journal. 1999 Nov 27; 319(7222): 1423–1425.

Quantification of disability or quality of life (3/3)

- The DALY approach currently in use presupposes that life years of disabled people are worth less than life years of people without disabilities.
- A valuation of human beings according to their functional capacity is in sharp contrast to the humanistic values laid down in the Declaration of Human Rights[1]: “recognition of the inherent dignity and of the equal and inalienable rights [unveräusserliche Rechte] of all members of the human family is the foundation.”
- “The healthier the person, the more valuable her life is to herself and to society and the greater their claim on healthcare resources to have their life extended.” This makes sense only if the value of life is not seen as a dimension distinct from health, but rather as a direct positive function of health, which is an oversimplification (to say the least).

→ instead of convoluting disability and quality of life into one metric, one shall <u>quantify disability in its own metrics</u>, and definitely abstain from converting this further into monetary units (as tempting it might be)

Source: [1]Universal declaration of human rights. 1948. Resolution 217A III UN General Assembly.

The (im)morality of discounting

- Investing 100$ now in a project that pays 300$ ten years from now is a financial success: it is equivalent to an annual rate of return of more than 11%.
- A policy that kills 100 people now in order to save 300 other lives ten years from now is not equally successful: there is no way to compensate the 100 people who paid the initial cost.
- The discussion of values without prices has a long history[1]: "Some things have a price, or relative worth, while other things have a dignity, or inner worth".
- No price tag does justice to the dignity of human life or the natural world. Since some of the most important benefits of climate protection are priceless, any monetary value for total benefits will necessarily be incomplete.

Source: [1]Immanuel Kant, 1785: Grundlegung zur Metaphysik der Sitten. F. Ackerman, 2009: Can we afford the future, ZED book, New York

Further reading

- Ackerman, F., 2009: Can we afford the future, ZED book, New York
- Ariely, D., 2008: Predictably irrational, The hidden forces that shape our decisions, Harper.
- Beinhoecker, E. D., 2006: Origin of Wealth: Evolution, Complexity, and the Radical Remaking of Economics. Harvard Business School press.
- Frederick, S. et al, 2002: Time Discounting and Time Preference: A Critical Review, Journal of Economic Literature Vol. XL (June 2002), pp. 351–401.
- Kahnemann, D., 2011: Thinking fast and slow. Macmillan.
- Picketty, T., 2014: Capital in the Twenty-First Century.