Comparing costs and benefits in climate change models

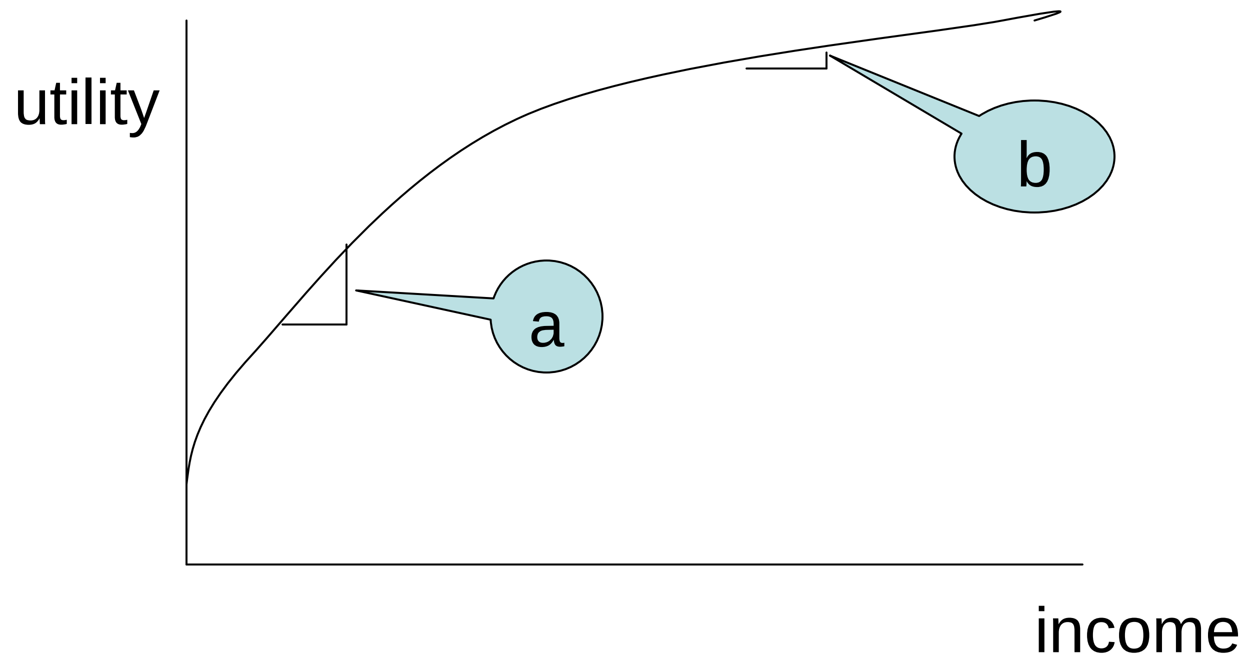
December 5

The basic point

- Costs of reducing emissions, and the costs of climate change, occur to people in different locations and at different points in time.
- Abatement costs are likely to fall on people in the near term, in richer countries.
- Costs of climate change are likely to fall most heavily on poorer people, in the (possibly distant) future.
- A cost-benefit analysis of abatement effort requires that we make these costs comparable.

Comparing costs over different income groups

- “Decreasing marginal utility of income” says that an extra dollar is worth less to a rich person than to a poor person. Compare the magnitudes “a” and “b”.



Weighting costs for different income groups

- Suppose that one dollar is worth 50% more to a poor person than to a rich person.
- Suppose that a “project” (e.g. reducing CO_2 concentration) costs the rich 1 unit of income (e.g. $100 billion).
- By how much (x) does the project have to increase poor income by (e.g. by avoiding costs that they incur from climate change) for the project to increase welfare?
- Answer: $x(1.5)>1$, i.e. $x>.66$
- I multiplied x (the savings to the poor) by 1.5 because (by assumption) one unit of income for rich is worth 1.5 units of income to poor.

Discussion of example

- This example says that the project increases aggregate utility if it saves the poor at least .66 units of income.
- I used the “price” 1.5 to convert units of “income to poor” into “income to rich”.
- (We use prices all the time to make the values of different goods – apples and oranges – commensurable.)
- Practical significance: In the Stern report, weighting the income of the poor more heavily leads to an increase from 15% to 20% of the estimate of value of annual reduction in gross world product, due to concentration of 550 ppm of GHG.

Effects of giving higher weight to income of poor

- Since climate change is more likely to harm the poor than the rich, increasing the weight given to the poor (in the cost benefit analysis) increases the estimated cost of climate change.
- This weighting scheme leads to an increase in the recommended level of abatement (and the costs of abatement) that society should be willing to incur.

Arguments for and against this kind of weighting

- Pro: It reflects a reasonable ethical judgment.
- Con: (i) The weights are very subjective. You can get "any kind of answer" by choice of weights. This subjective element reduces the value of the exercise.
- Con: (ii) Climate change policy is an inefficient means of transferring income. We have more efficient methods of transferring income.

Elaborate on efficiency argument

- Suppose (using my example above) that the project costs the rich 1 unit of income and increases the income of the poor by 0.8 units. This project increases world welfare, because 1.5(0.8)>1.
- However, both the rich and the poor would be better off if the rich simply gave the poor 0.9 units of income, rather than undertaking the project.
- The same logic holds whenever the project increases income of poor by less than 1 unit of income.
- Thus, the test for efficiency of the project is not related to the weight we give to the income of the poor.

More on the efficiency argument

- The basic point of the argument against using different weights on income of rich and poor is that doing so encourages viewing climate change policy as a means of redressing income inequality.
- Climate change policy should be “targeted” to the problem of climate change, not to the problem of unfair income distribution. Climate change policy would be a very “leaky bucket” if it were used to transfer income.

Two examples of costs and benefits of climate change policy

	rich	poor	Total
costs	1	0	1
benefi ts	.0	.7	.7 (1.05)

	rich	poor	total
Costs	1	0	1
benefits	.3	.4	.7 (0.9)

- Number in ( ) shows weighted benefits as in example.
- If we use equal weights for the rich and the poor benefits, neither of these projects should be undertaken.
- If we weight the poor benefits by 1.5 of rich benefits (as in my example), the first but not the second project should be undertaken.

Comparing costs and benefits over time

- Discuss above considered whether costs and benefits for different income groups should be weighted equally.
- Now I want to consider how to “add up” costs and benefits that occur at different points in time.
- In order to do this, we use a discount factor.

Discount rates and discount factors

- If I face an annual interest rate of 5%, I am indifferent between \$0.9524 today and \$1 in one year: investing \$0.9524 for one year gives me (1.05)0.9524=1.
- If I face an annual interest rate of r%, I am indifferent between 1/(1.0+.0r) today and \$1 in one year.
- (The numerical value of a discount rate of 5% is .05, so the numerical value of a discount rate of r% is .0r.)
- 1/(1+.0r) is the one year discount factor corresponding to a one year interest rate (also called the “discount rate”) of r%.
- The discount factor is the “price” today of one dollar in one year.
- *A larger discount rate translates to a smaller discount factor.*

The “tyranny” of compound discounting

- The “price” today of one dollar n years from now is 1/(1+.0r)**n. (1/(1+.0r)) raised to the n)
- This is the amount that I would be willing to pay today (e.g. in order to reduce GHG emissions) to avoid having to pay $1 (e.g., resulting from climate change) n years from now.
- Table shows amount we would pay today to avoid $100 in damages at different future times.

	100 years from now	200 years from now
3% discount rate	$5.2	$0.27
6% discount rate	$0.29	$0.0009

- With a non-negligible discount rate, we would not spend much to avoid damages in the distant future

The social discount rate

- The social discount rate is used to compare costs and benefits at different points in time for a public project (such as climate change policy).
- It is analogous to the private discount rate (or interest rate), except that it reflects society’s preferences and opportunity costs, rather than the individual’s.
- If the annual social discount rate is r, the discount factor for n years in the future (the “price” today of one dollar of income n years in the future) is 1/(1+.0r)**n. (“**” means “raised to the n”)

The components of the social discount rate

- The social discount rate equals:

  (pure rate of time preference) + (elasticity of marginal utility times growth rate of income).
- Pure rate of time preference reflects society's preference to consume earlier rather than later. A larger value means that we are more impatient.
- Elasticity reflects our willingness to have different income levels in different periods. A larger value means we care less about income equality over different periods in time (i.e. we care less about "smoothing" income over time)
- If income is growing, we are less willing to transfer income to the future.
- Larger social discount rate means that we put less weight on future.

Should the pure rate of time preference be constant?

- A pure rate of time preference of 5% means that society would be willing to give up $1.65 in ten years in order to avoid having to pay $1 today.
- How much would we be willing to take away from the generation living 210 years from now, in order to give $1 to the generation living 200 years from now?
- We can distinguish between individuals consuming now and ten years from now, so we might have a preference for one group rather than the other – leading to a positive pure rate of time preference for the near term.
- We can't distinguish between generations living in the distant future, so why should we have a positive pure rate of time governing consumption in the distant future?
- This argument suggests that the pure rate of time preference should be a decreasing function of "time in the future", possibly approaching 0.

Effects of a declining pure rate of time preference

- It makes us put more weight on the future.
- A declining pure rate of time preference also means that the optimal program is (typically) “time inconsistent”.
- One form of time inconsistency is the desire to procrastinate. We want to put off costs (or something unpleasant) until “the future”. But when the “the future” arrives, it has become “the present” – so we still want to put off costs.
- “Time inconsistent” programs are not “plausible”. It is technically harder to obtain “time consistent” programs. We need to solve a game amongst a succession of agents.

The economic value of reducing risks

- Risky events are those that might occur in the future. Since we incur costs today to reduce these risks, we need to compare the discounted future benefits to the current costs.
- We can measure the risk of an event (e.g. an abrupt increase in sea level) using a "hazard rate", which I call h. The hazard rate is the probability that the event occurs over a given unit of time (e.g. one year) given that it has not yet occurred.
- With typical social discount rates (e.g. 3-5%) we would not be willing to pay much to reduce the risk of a low probability event.

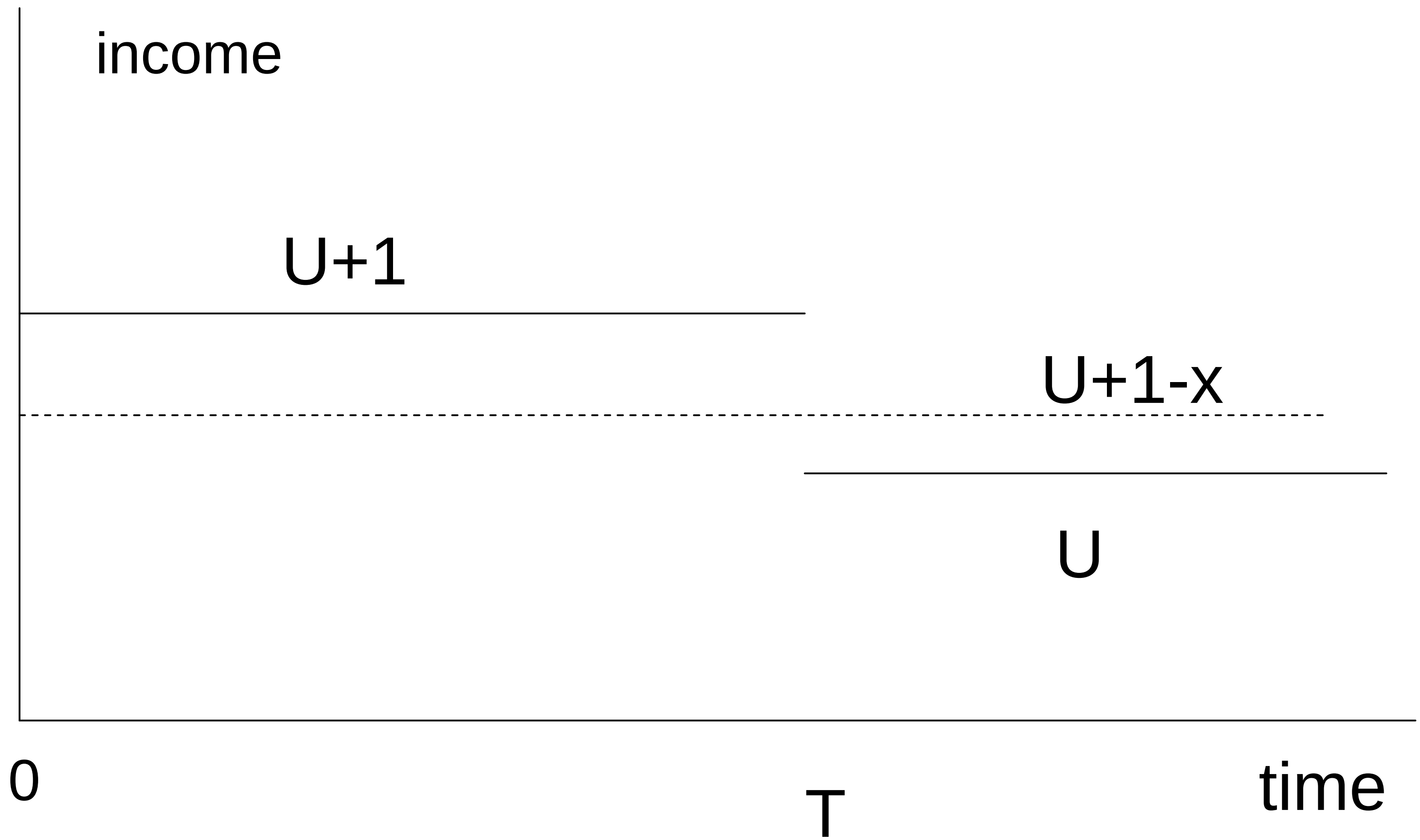
The reason we would not spend much to reduce these risks

- Low probability events are those with low hazard rates (h).
- These events are not likely to occur until the distant future.
- With non-negligible discounting, we don’t care about the distant future.
- (But the distant future lasts a long time.)

Example to show magnitudes

- Suppose that an “event” (which occurs at a random time) reduces *flow* of utility by 1 util (e.g. 1 util = $100 billion per year).
- Let h = constant hazard rate of this event.
- Suppose that we can eliminate the risk (set h=0) by sacrificing the *flow* x.
- What is the maximum amount that we would be willing to give up in order to eliminate the risk?

Solid line: graph of utility flow if “the event” occurs at (random) time T. Dashed line: graph of utility flow when risk is eliminated



How much would we spend to eliminate risk?

- The expected resent discount value (PDV) of the risky flow is 1/(r+h).
- The PDV of the safe flow is (1-x)/r.
- The largest x we would accept in order to eliminate the risk is x*= h/(h+r)
- If r=0.05 and there is a 5% risk of occurrence per century, x*=.01 (WTP is 1% of value at risk.)

Point of this example

- This example shows that if we have a constant and non-negligible pure rate of time preference, and if the hazard rate is low, we should not spend much to eliminate the risk.
- The model leading to this conclusion is “coherent” (logically correct), but it is based on the assumption that the pure rate of time preference remains much greater than 0.
- Models that assume that pure rate of time preference remains much larger than hazard rate have a “built in” conclusion that it is not worth spending much to reduce the risk.
- The conclusions of these models are based on an implicit ethical judgment, not just on “science”.

A different view

- If the pure rate of time preference declines (as I argued above that it “should”), a cost benefit analysis implies that society should be willing to spend much more in order to reduce the risk of low probability catastrophic events. (See the paper “Discounting” in the box of lecture notes.)