The Economics of time discounting (2)

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An outline of the lectures

- Lecture 1: An introduction to economic risky decision making. Expected Value and Expected Utility.

- Lecture 2: Beyond Expected Utility: Prospect theory, non-linear probability weighting, loss aversion, WTA/WTP gap.

- Lecture 3: The economics of time discounting. A brief history of time preferences and the models used to describe time preferences.

- Lecture 4: Applications of time discounting in fields of economics, with a particular focus on environmental economics.

Up until now

- In the previous lecture we saw an introduction to intertemporal preferences for economic decision making.

- We saw the basic time discounting approaches: exponential discounting, hyperbolic discounting and quasi-hyperbolic discounting.

- We saw some important concepts deriving from these models like time inconsistency, procrastination and naivety/sophistication.

- Finally, we saw a couple of applications and we discussed about the origins for non-constant time discounting.

In today's lecture

- In the lecture today we will continue our discussion about intertemporal choice and time discounting.

- We will see some common "anomalies" of the DU (Discounted Utility) model and we will illustrate them through examples.

- We will also examine recent applications from agricultural economics to see the determinants of time discounting and from environmental economics with a particular focus on the problem of climate change.

- The lecture today will be more applied-oriented than the previous one.

Confounding factors when measuring time preferences

- There are a number of factors which can be involved in the elicitation of time preferences and they can be confounded when we attempt to measure time preferences, that is, the value of discount rare could be compromised by other factors. We refer to some of them briefly. See Frederick et al. (2002) for a reference.

- Consumption reallocation: it is assumed that the rewards are consumed immediately and they are not reallocated and consumed across time. This might not be the case in reality.

- Intertemporal arbitrage: when we have tradeable goods (like money), arbitrage opportunities (exploiting financial opportunities and price differences) might be relevant. This could "mask" true time preferences.

Confounding factors when measuring time preferences

- Concave utility-Utility change: There are two factors here; the first, is that the utility of consumption is not taken into account (utility is considered to be linear). If utility is considered, the values of discount rate could change than previously. The second is that marginal utility could change across time due to expectations of obtaining greater wealth in the future.

- Inflation: if people experience live in an environment of inflationary pressures, then people might discount according to the inflation rate.

Confounding factors when measuring time preferences

- Uncertainty: The uncertainty of delivering (or not) the future rewards is something that is not considered in economic analysis. In economic experiments, the experimenters are trying to eliminate this problem by ensuring the delivery of future rewards.

We will see the role of uncertainty later in the context of long-term horizon discounting process.

A few problems

- A number of irregularities have been documented in the literature with respect to time discounting and the initial discounting utility model of Samuelson.

- Let's see some of them analytically and try to explain what exactly is happening.

Anomalies
Intertemporal Choice

Loewenstein and Thaler (1989),
Journal of Economic Perspectives.

The sign effect

- The sign effect states that losses (negative rewards) are discounted less than equivalent gains.

- Thaler (1981) was one of the first who reported this finding in the literature.

- In practice this means that people are more eager to get a positive reward (large discounting) and at the same time they are less anxious to postpone a loss. This may be due to "debt aversion", people want to avoid debt and pay off their debts quickly (Loewenstein and Thaler, 1989).

The magnitude effect

- The magnitude effect states that people tend to discount less larger rewards than smaller ones.

- This means that an individual would prefer £5 now rather than £10 in a year, but when this is increased by a factor of say, 10, they would prefer £100 in a year rather than £50 now.

- So, in the first case the discounting is larger compared to the second case, thus, the larger rewards could bring down the discount rate.

The date/delay effect

- How much you want to receive in 8 months, so that to be equivalent to receiving £100 now?

- How much you want to receive on __mm / dd__ so that to be equivalent to receiving £100 now?

- How would you respond to the above questions? They look very similar, don't they?

- Of course if you look at the dates, you will see that the two questions are identical.

- The difference is that the date of delivery for the future reward is denoted differently.

The date/delay effect

- Would you expect any difference in the answers of participants in an experiment between these two questions?

- It has been found that participants demand more money in the first question where the delay is described by the amount of time to be waited than when it is described by the wait's endpoint (the exact date).

- Subsequently, this means that in the first question the discount rate is higher.

- LeBoeuf (2006) explains that this could happen because when the date is indicated by a date, it is considered an abstract point in time and people cannot understand the time delay length.

The delay/speed up asymmetry

- Let's see an asymmetry reported by Loewenstein (1988): in an experiment, students were given $7 gift certificate from a local shop. However, the time after which the certificates will be given varies among 1,4,8 weeks.

- Subsequently, the students were given the possibility to keep the certificate (at the original appointed time) or to trade it for a smaller certificate received earlier or a larger certificate received later.

- Some students made a tradeoff between the certificate and the delay (from week 1 to week 4) while other students made a tradeoff between the certificate and its speed-up (from week 4 to week 1).

- What is the point of this experiment? It practically allows the role of the reference point to be examined.

Table 1

Mean Amounts to Speed-up and Delay Consumption
($7 Record Store Gift Certificate)

Time Interval	Delay	Speed-up	Significance
1 week versus 4 weeks	$1.09	$.25	.001
4 weeks versus 8 weeks	$.84	$.37	.005
1 week versus 8 weeks	$1.76	$.52	.001

The delay/speed up asymmetry

- The results are shown in the adjacent table.

- You can see that, for all three comparisons, the mean delay premium is at least twice the mean speed-up cost (statistically significant results).

- That is, students have a higher premium for waiting (past the initial date) than for speeding up the initial date.

- Note that this can be interpreted in the context of loss aversion in Prospect Theory, the idea of losing an amount of money is greater than the utility of gaining the same amount.

Present bias

- Present bias refers to situations where an individual (or even animals) prefer rewards which are closer to the present (small sooner rewards).

- As we have seen this is an important parameter of time discounting that modelling approaches have attempted to follow.

- Note that this might change if the choice between both the SS reward and the LL reward were one year later from today (the same distance is added). Then more people could prefer the LL reward.

The common difference effect

- A person who is indifferent between say 20 today and 25 in one month, most likely will switch to 25 in eleven months to 20 in ten months.

- So, this means that adding a common delay of 10 months could switch preferences towards the LL reward (some call this the reverse time inconsistency).

- Formally, this is expressed analytically below:

$$(x, t) \sim (y, t'),$$
$$(x, t + \epsilon) \prec (y, t' + \epsilon),$$
$$y > x, \epsilon > 0$$

Are the anomalies just mistakes?

- The aforementioned effects might be viewed as "anomalies" in the context of DU model but this does not mean that they violate any principle of intertemporal preferences.

- As a result, the appearance of such "anomalies" should not be viewed as mistakes by the respondents but rather as just some effects which could well appear when investigating intertemporal preferences.

- At the same time they could be used for policy purposes where necessary e.g., during investment decisions it might be better or people to think in calendar dates because this will mean lower discount rates and will make investment decisions easier.
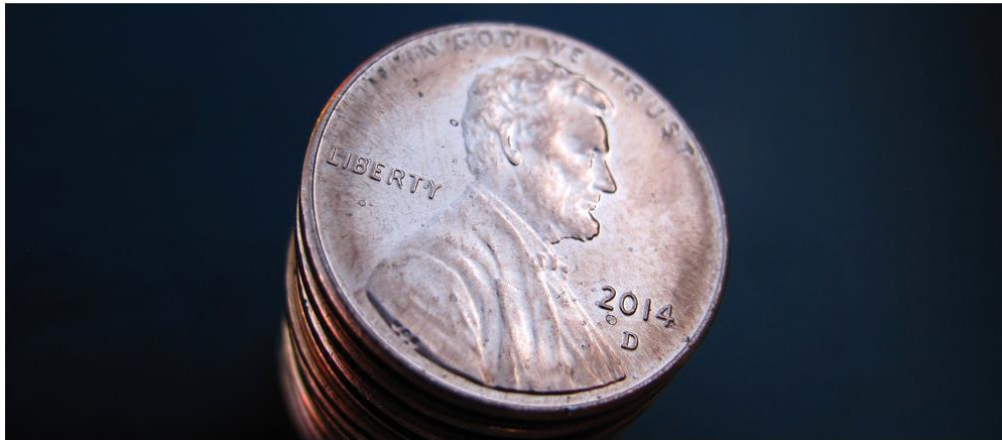
More advanced models

- Note that these "anomalies" discussed earlier have paved the way for the creation of more complicated models to describe human attitudes in an intertemporal setting.

- Such models are habit-formation models, anticipation utility models, reference point models, models that incorporate visceral influences etc.

- We are not going to discuss them here but if you wish to learn more you could consult Frederick et al. (2002), section 5.2.

An example on savings

An application where hyperbolic discounting features prominently is the case of undersavings for retirement.

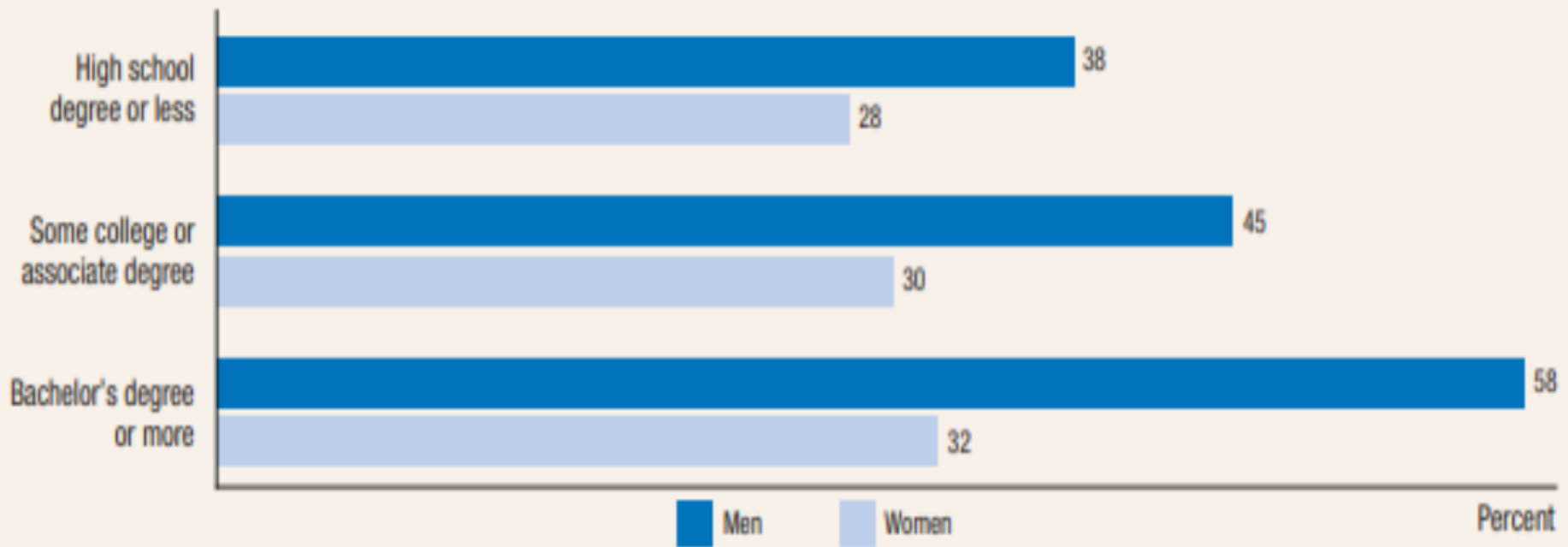## A quarter of Americans have no retirement savings

Scraping pennies.

Image: REUTERS/Mike Bla[k]

13 Jun 2019

A quarter of non-retired adult Americans have no retirement savings or pension a[t] all. Only 36% think their savings are on track.

In simple words, this means that many people do not balance properly their consumption across time and as a result they don't put aside enough money for their retirement (401(k) plan in the US).

Figure 35. Mostly or very comfortable investing self-directed retirement savings (by gender and education)

Education	Men	Women
High school degree or less	38	28
Some college or associate degree	45	30
Bachelor's degree or more	58	32

Note: Among non-retirees with a self-directed retirement account.

https://www.weforum.org/agenda/2019/06/a-quarter-of-americans-have-no-retirement-savings/

- People without obligatory pension schemes tend to save less than otherwise (Thaler and Sefrin, 1981).

- This is an important policy question with potential significant ramifications.

- The data in the previous page comes from the World Economic Forum (WEF) in Switzerland.

- This is data from a US survey.

- As you can see, even with a degree many people are not comfortable with basic financial literacy although if you have at least a bachelor's degree things look better.

- Women also tend to suffer more from this problem and to save less money.

- What does this mean? Ultimately some people might be forced to work more than they initially planned.

- Controlling for hyperbolic discount has been shown that it can explain why savings plan might not work (Laibson, 1996).

- People tend not to have a constant discount rate and they exhibit a bias for consumption at the present (present bias). In turn, this results in less savings for the future (i.e., undersaving).

Back to health economics

- The time dimension is also taken into account in health economics.

- A technique that is used in this economic field is the Time Trade-Off (TTO): a choice is made between enjoying a good but shorter health state and a lengthier but less than perfect health state.

- This choice could be related to specific health attributes and could even include multiple health states (see examples in the next slide).
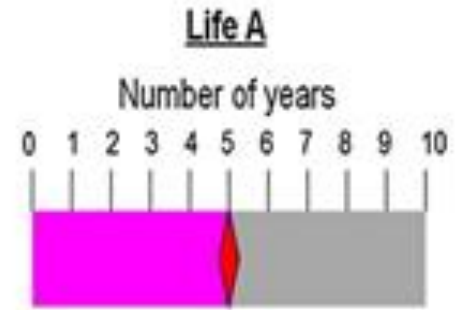
Fig. 3 The visual aids used in the MVH and Paris protocols. a Visual aid for valuation of states considered to be better than death

a

Life A

No problems in walking about
No problems with self-care
No problems doing usual activities
No pain or discomfort
Not anxious or depressed

Number of years
0 1 2 3 4 5 6 7 8 9 10

Life B

No problems in walking about
No problems with self-care
No problems doing usual activities
Moderate pain or discomfort
Moderately anxious or depressed

Number of years
0 1 2 3 4 5 6 7 8 9 10

Source: Oppe et al. (2016)
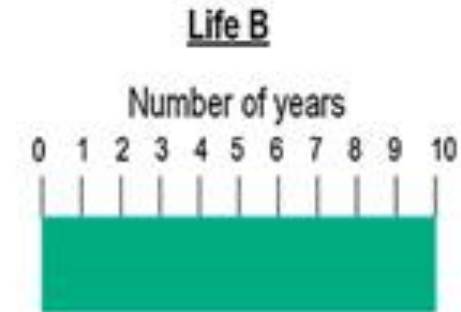
| 9 years in health state A	4 years in health state B	4 years in full health

Fig. 2. Display of the intertemporal health profiles.

Source: Abellan-Perpiñan et al. (2009)

- As with the standard gamble, by varying the time length between the two choices one determines the indifference point.

- A discounted utility function across health profiles can also be used under similar rationale as previously explained (discounted QALY model):

$$U(q_1, q_2, \ldots, q_t)$$
$$= \sum_{t=1}^{T} \frac{1}{(1+r)^t} H(q_t)$$
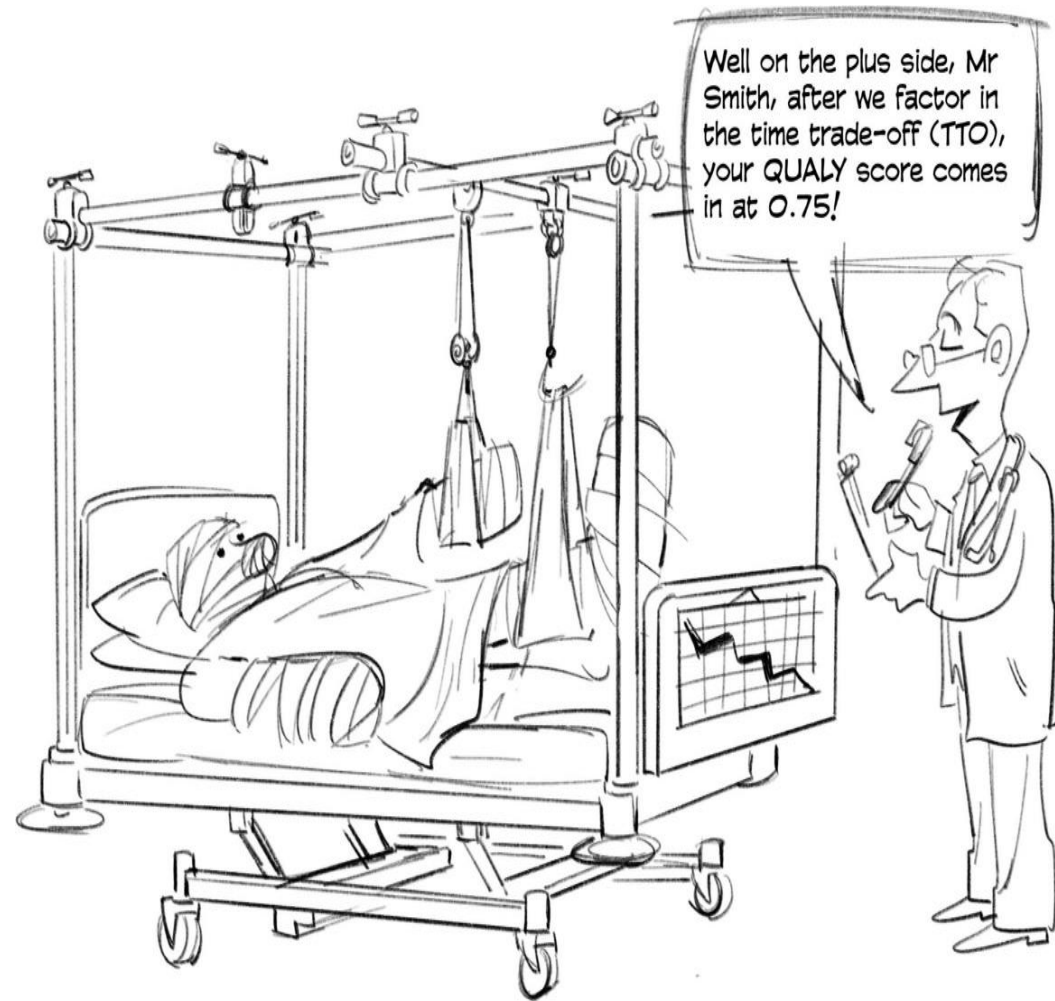
Framing in the elicitation of time preferences

- We discussed about the role of framing in the context of risky decision making.

- But what about the impact of framing effects when eliciting time preferences and discount rates?

- Manzini et al. (2014) have elicited time preferences under three different experimental approaches and show that the results are sensitive to the selection of the experimental approach.

- More precisely, they find that discount rates elicited through multiple price lists are higher than the other two methods.

Figure 3: Sample screenshot with the elicitation question for the auction method

4 Months

I prefer to receive € (enter a value between 0.50 and 20) [____] | Choice

in order to obtain the payment tomorrow, rather than receive the whole amount (20€) in four months

CEEL

VERSION 1 MONTH

	Option A (payable tomorrow)	Option B (payable in 1 month)
If this row is drawn :	I prefer to receive tomorrow 20.00€	I prefer to receive 20€ in one month
If this row is drawn :	I prefer to receive tomorrow 19.50€	I prefer to receive 20€ in one month
If this row is drawn :	I prefer to receive tomorrow 19.00€	I prefer to receive 20€ in one month
If this row is drawn :	I prefer to receive tomorrow 18.50€	I prefer to receive 20€ in one month
If this row is drawn :	I prefer to receive tomorrow 18.00€	I prefer to receive 20€ in one month
If this row is drawn :	I prefer to receive tomorrow 17.50€	I prefer to receive 20€ in one month
If this row is drawn :	I prefer to receive tomorrow 17.00€	I prefer to receive 20€ in one month
If this row is drawn :	I prefer to receive tomorrow 16.50€	I prefer to receive 20€ in one month
If this row is drawn :	I prefer to receive tomorrow 16.00€	I prefer to receive 20€ in one month
If this row is drawn :	I prefer to receive tomorrow 15.50€	I prefer to receive 20€ in one month
If this row is drawn :	I prefer to receive tomorrow 15.00€	I prefer to receive 20€ in one month
If this row is drawn :	I prefer to receive tomorrow 14.50€	I prefer to receive 20€ in one month
If this row is drawn :	I prefer to receive tomorrow 14.00€	I prefer to receive 20€ in one month
If this row is drawn :	I prefer to receive tomorrow 13.50€	I prefer to receive 20€ in one month
If this row is drawn :	I prefer to receive tomorrow 13.00€	I prefer to receive 20€ in one month
If this row is drawn :	I prefer to receive tomorrow 12.50€	I prefer to receive 20€ in one month
If this row is drawn :	I prefer to receive tomorrow 12.00€	I prefer to receive 20€ in one month
If this row is drawn :	I prefer to receive tomorrow 11.50€	I prefer to receive 20€ in one month
If this row is drawn :	I prefer to receive tomorrow 11.00€	I prefer to receive 20€ in one month
If this row is drawn :	I prefer to receive tomorrow 10.50€	I prefer to receive 20€ in one month
If this row is drawn :	I prefer to receive tomorrow 10.00€	I prefer to receive 20€ in one month
If this row is drawn :	I prefer to receive tomorrow 9.50€	I prefer to receive 20€ in one month
If this row is drawn :	I prefer to receive tomorrow 9.00€	I prefer to receive 20€ in one month
If this row is drawn :	I prefer to receive tomorrow 8.50€	I prefer to receive 20€ in one month
If this row is drawn :	I prefer to receive tomorrow 8.00€	I prefer to receive 20€ in one month
If this row is drawn :	I prefer to receive tomorrow 7.50€	I prefer to receive 20€ in one month
If this row is drawn :	I prefer to receive tomorrow 7.00€	I prefer to receive 20€ in one month
If this row is drawn :	I prefer to receive tomorrow 6.50€	I prefer to receive 20€ in one month
If this row is drawn :	I prefer to receive tomorrow 6.00€	I prefer to receive 20€ in one month
If this row is drawn :	I prefer to receive tomorrow 5.50€	I prefer to receive 20€ in one month
If this row is drawn :	I prefer to receive tomorrow 5.00€	I prefer to receive 20€ in one month
If this row is drawn :	I prefer to receive tomorrow 4.50€	I prefer to receive 20€ in one month
If this row is drawn :	I prefer to receive tomorrow 4.00€	I prefer to receive 20€ in one month
If this row is drawn :	I prefer to receive tomorrow 3.50€	I prefer to receive 20€ in one month
If this row is drawn :	I prefer to receive tomorrow 3.00€	I prefer to receive 20€ in one month
If this row is drawn :	I prefer to receive tomorrow 2.50€	I prefer to receive 20€ in one month
If this row is drawn :	I prefer to receive tomorrow 2.00€	I prefer to receive 20€ in one month
If this row is drawn :	I prefer to receive tomorrow 1.50€	I prefer to receive 20€ in one month
If this row is drawn :	I prefer to receive tomorrow 1.00€	I prefer to receive 20€ in one month
If this row is drawn :	I prefer to receive tomorrow 0.50€	I prefer to receive 20€ in one month

OK

Figure 2: Sample Screenshot for MPL elicitation method

Some similarities between risk and time preferences

- Up until ow, we have discussed quite extensively about risk attitudes and also about time preferences.

- A question might arise naturally: is there any connection between these two different types of preferences?

- Prelec and Loewenstein (1991) are referring to some similarities which are summarized in the next slide.

- This does not mean that risky and intertemporal choice are the same but some similarities might not be unexpected given that they are typically correlated with one another in real world applications.

Some similarities between risk and time preferences

Time preferences		Risk preferences	
Gain-loss asymmetry	Lower devaluation of losses	Reflection effect	Risk seeking towards losses
Magnitude effect	Lower devaluation of large than small gains/losses	"Peanuts effect"	Risk taking for small gains and risk aversion for small losses
Common difference effect	$(x,t) \sim (y,t')$, $(x, t+\epsilon) \prec (y, t'+\epsilon)$, $y > x, \epsilon < 0$	Common ratio effect	$(x,p) \sim (y,q)$, $(x, ap) \prec (y, aq)$, $y > x, 0 < a < 1$
Framing effects/ Delay speed up & reference point	Sensitivity to description of objectively equivalent prospects	Framing effects	Sensitivity to description of objectively equivalent prospects

An application from agricultural economics

- In the 2nd lecture we saw an application from the field of agricultural economics about small-cattle farmers in West Africa, Mali and Burkina Faso (Liebenehm and Waibel, 2014).

- This study also included the elicitation of time preferences by using a quasi-hyperbolic discounting approach, $D(t) = \beta e^{-\delta t}$.

- In the homogeneous model it is $\beta = 0.942, \delta = 0.006$, so discount rate is quite low and farmers do not exhibit high levels of impatience.

- When demographic characteristics are included, poverty is associated with higher levels of impatience (higher discount rate)

An application from agricultural economics

- Education also impacts negatively the discount rate (lower discount rates) (farmers with more children in school place a higher value on future benefits).

- Discount rate increases with age (this might be related with low life expectancies in West Africa).

- Religion is negatively related with the discount rate (farmers who

  rely more on God's goodwill are more likely to wait for larger returns in the future).

  Finally, household size is also associated with higher discount rate (more people in the household, the higher the discount rate).

Time preferences among different countries

- Wang et al. (2016) examined time preferences among individuals in 53 different countries and 6912 students from all continents. See the table in next slide.

- Discount rate is higher for 1 year than for 10 years: hyperbolic discounting is a global phenomenon.

- Time discounting for short time horizons exhibit larger heterogeneity than time discounting for longer time horizons.

- What about some cultural indicators? We will focus on two of them: Individualism (A high score of Individualism implies that individuals are loosely connected to the society, and are expected to take care of themselves).

Table 1: Overview of countries in the sample

Country	N	Country	N	Country	N
Angola	57	Germany	540	Norway	192
Argentina	58	Greece	58	Poland	270
Australia	151	Hong Kong	101	Portugal	137
Austria	150	Hungary	262	Romania	339
Azerbaijan	122	India	61	Russia	162
Belgium	46	Ireland	194	Slovenia	96
Bosnia &Herz.	74	Israel	127	South Korea	105
Canada	84	Italy	81	Spain	45
Chile	100	Japan	274	Sweden	65
China	256	Lebanon	101	Switzerland	483
Colombia	147	Lithuania	105	Taiwan	100
Croatia	115	Luxembourg	44	Tanzania	60
Czech Rep	49	Malaysia	99	Thailand	44
Denmark	73	Mexico	89	Turkey	133
Estonia	126	Moldova	100	UK	62
Finland	124	Netherlands	88	USA	72
France	138	New Zealand	91	Vietnam	131
Georgia	38	Nigeria	93	**Total**	**6912**

- Long Term Orientation (It reflects to what extent a society has a dynamic future-oriented mentality; A high score implies that the past is valued less than the future). Long Term Orientation Score is typically high in East Asia, especially in Confucian cultures. It implies that people in such cultures tend to put higher value on the future, and they are more likely to be patient.

- Wang et al. (2016) found that both higher degree of Individualism and Long Term Orientation predict a stronger tendency to wait for larger payoffs.

- For all participants, the median value of β is 0.60 while the median value of δ is 0.82. The variation in the present bias discount factor β is much higher than the variation in the long-term discount factor δ.
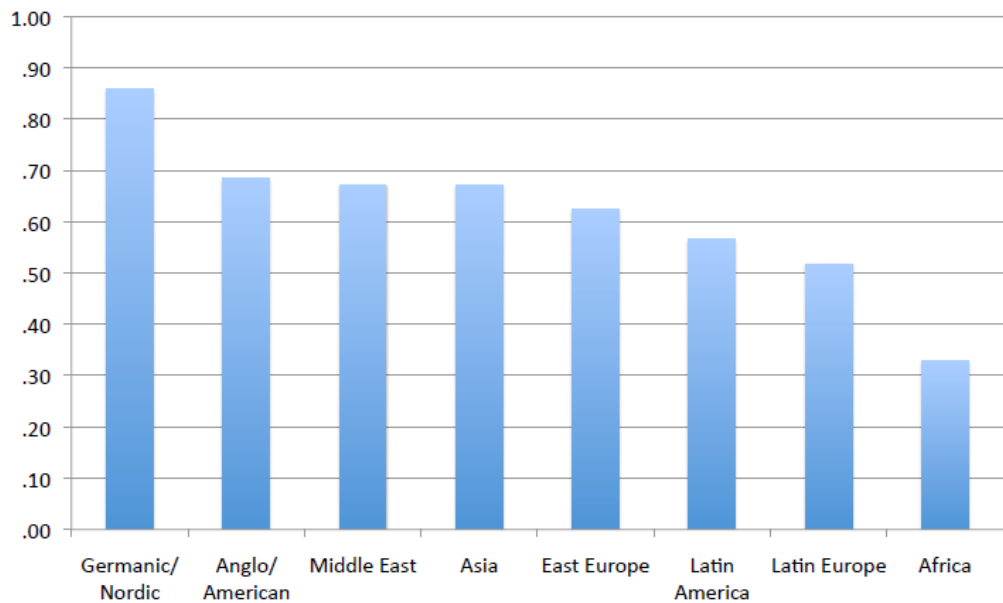
Which offer would you prefer?

A. a payment of $3400 this month

B. a payment of $3800 next month

Figure 1: The percentage of choosing to wait grouped by cultural origin

Note: The column shows the percentage of participants who chose the $3800 option when they were asked to choose between $3400 this month or $3800 next month. The respondents were asked about which culture they thought they belong to. We group the countries into seven cultural clusters inspired by the classification from Chhokar, Brodbeck, and House (2008).
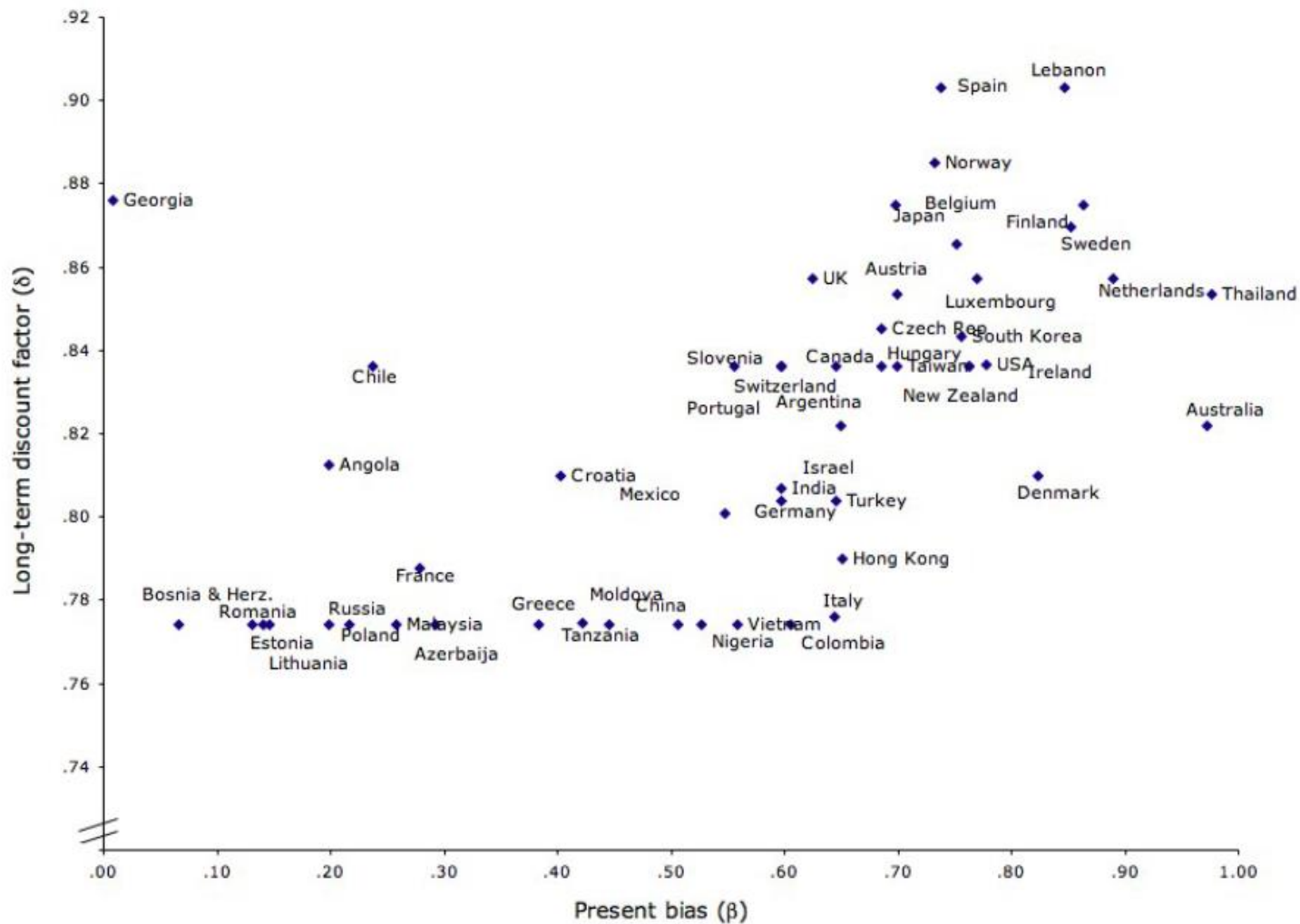
Figure 3: Median values of Parameters in Hyperbolic Discounting Model for All Countries

Looking far ahead

- A very timely example: How would one assess long term projects?

- Like for example reducing greenhouse gas emissions?

- Or how about valuing biodiversity and halting the accelerated biodiversity loss threatened by human activity?

- Or what about projects that could serve communities for decades to come, like major infrastructure projects?

- This is a difficult question with long time horizon: benefits will be enjoyed by future generations but costs are borne today. So, the selection of the discount rate could be important for policy-making.

- Stern (2006) writes: "Discounting, as generally used in economics, is a technique relevant for marginal perturbations around a given growth path. A discount rate that is common across projects can be used only for assessing projects that involve perturbations around a path and not for comparing across very different paths."

- A question that emerges: How can one make a reliable assessment of such projects?

- Such projects are typically assessed through a cost-benefit analysis (CBA) where a number of future costs and future benefits are considered.

- Of course, a number of factors have to be considered in order the analysis to be reliable e.g. detailed analysis of costs-benefits, regulatory analysis, social welfare, intergenerational equity concerns, considerations about risk and uncertainty etc.

GUIDELINES FOR PREPARING
ECONOMIC ANALYSES
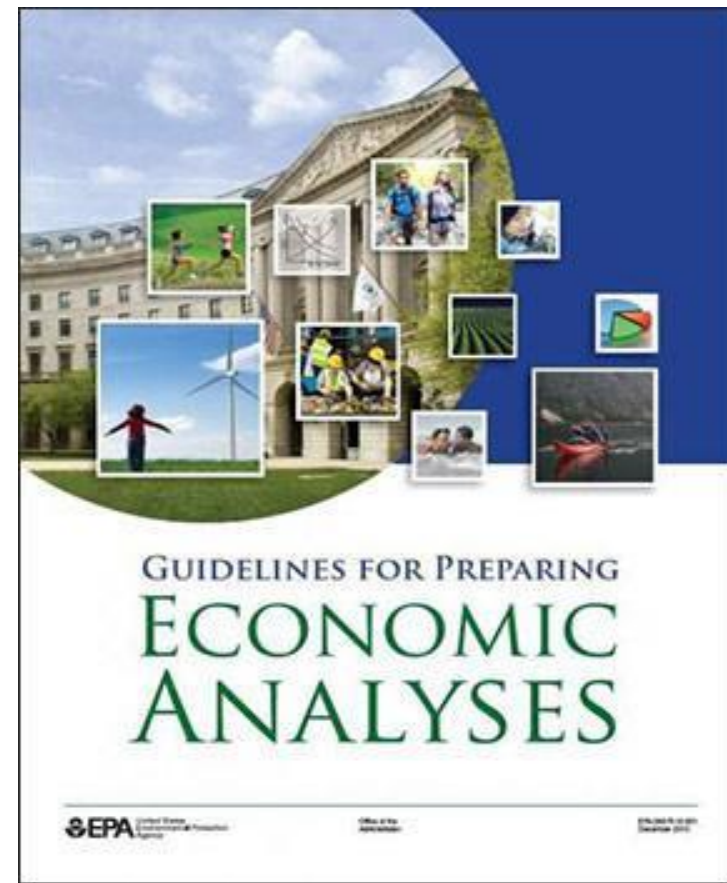
- Generally, in cost-benefit analysis one estimate the net benefits: $NB_t = B_t - C_t$.

- Then, these costs and benefits have to be discounted at an appropriate rate:

$$NB_t = \sum_0^t \frac{B_t - C_t}{(1+r)^t}$$

- But what value to assign to r? How to measure it?

- The value of discount rate is crucial and could have an impact on the final decisions reached.

An application

- Consider the following table which shows benefits for two different programs over a short period of 4 years. Which project would you choose? Project 1 or 2?

- Assume first a discount rate at 6%.

- Note that the total Net Benefits (NB) are the same (80) after the four time periods. To make an accurate assessment, we have to calculate the Present Value of each Project.

	Present	Year 1	Year 2	Year 3	Total NB
Project 1	20	20	20	20	80
Project 2	50	10	10	10	80

- $PV_1 = 20 + \frac{20}{1+0.06} + \frac{20}{(1+0.06)^2} + \frac{20}{(1+0.06)^3} = 73.45$

- $PV_2 = 50 + \frac{10}{1+0.06} + \frac{10}{(1+0.06)^2} + \frac{10}{(1+0.06)^3} = 76.73$

- So, you can see that Project 2 is preferred over Project 1. Notice that the present values for each period are less than the undiscounted Total Net Benefits (80).

- Notice that changing the discount rate could affect the numbers of the Present Value for each Project.

- For example, if we choose a discount rate at 0.01% (very low admittedly), then $PV_1 = 79.9$, $PV_2 = 79.95$, so the numbers are very close.
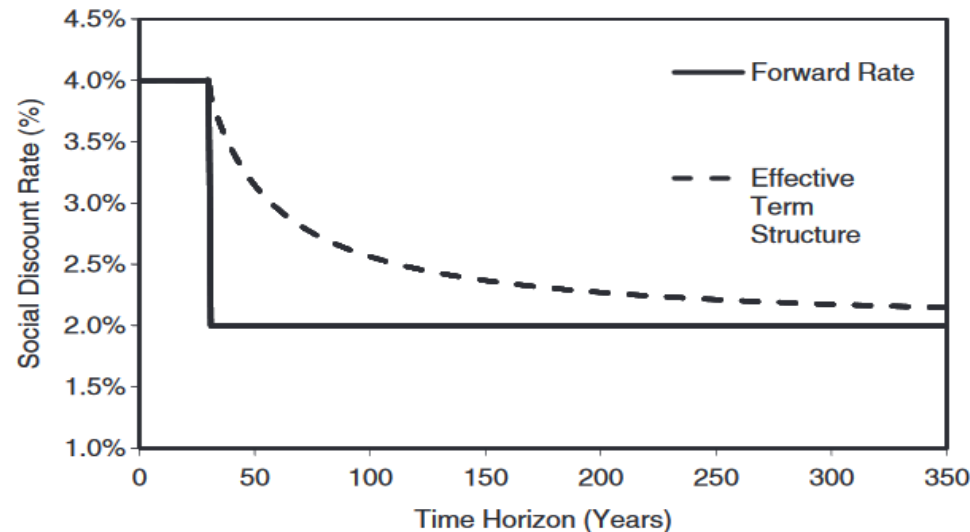
Social discount rate

- Discounting over very long time horizons can be complicated due to the fact that elicited discount rates (and market interest rates) are at the individual level.

- Moreover, future generations do not have a say in this assessment, these are the intergenerational concerns.

- A final consideration is that long time horizon investments involve uncertainty (risk that cannot easily be calculated) and this has to be considered in the selection of the discount rate.

- So, selecting a social discount rate for the welfare of the society it is a complicated process and for which there is no exact answer.
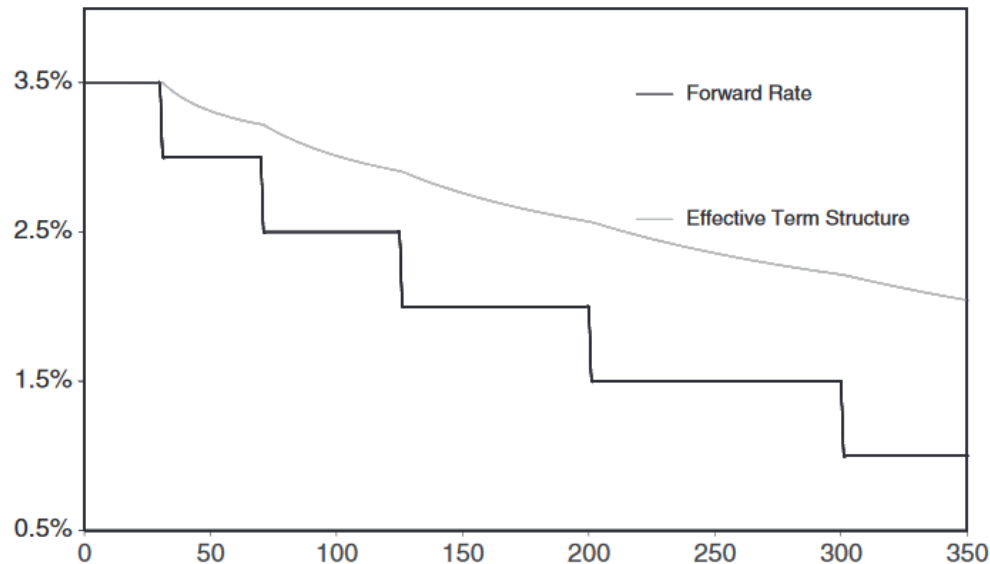
- There is no straightforward answer in selecting a discount rate. Different approaches by different agents (countries) are possible.

- In France, the discount rate is 4% for the first 30 years and falls to 2% thereafter.

Figure 2 The French government social discount rate term structure

Source: Arrow et al. (2014).

Figure 3 The UK government social discount rate term structure

Source: Arrow et al. (2014).

- In UK, the discount rate has a more complicated structure; a kind of step function has been adopted with different changes per year.

- The graph shows a 3.5% discount rate for the first 30 years; this discount rate continues to decline across timer.

- Ultimately, it could reach values equal to 1% for 301 years and beyond.

- In either case, the discount rate declines over time. By contrast, in the US a different approach has been advocated: discount rate can be constant, but it can change (updated) over time.

- Nonetheless, it is a complicated process that could have an impact on future generations who are not represented during policy making.

Intergenerational equity

A concern that arises due to discounting is related to intergenerational equity. This about issues of fairness among different generations since future generations will "face losses" if global warming continues.

A way to deal with this issue is to adopt a very low discount rate so that these concerns to be "spread" to present and future generations a high discount rate means that environmental amenities might not be there for future generations.

Intergenerational concerns are at the heart of sustainability and the sustainable development concept (about the proper use of resource, waste management etc.).

Yellowstone national park

Yellowstone is a national park, the first national park in the US (and probably in the world).

It was declared as a national park in 1872, by President Grant.

What does this mean about the selection of the discount rate for the environmental amenities of the park? What is the discount rate that was selected?

"the headwaters of the Yellowstone River … is hereby reserved and withdrawn from settlement, occupancy, or sale … and dedicated and set apart as a public park or pleasuring-ground for the benefit and enjoyment of the people."

Green transition and discount rates

- You might be aware about the green transition from non-renewable (fossil fuels) to renewable sources of energy (wind, solar, etc.).

- How the selection of the discount rate could influence this process?

- Such ambitions require large scale upfront investments. These costs will be felt in the present. The benefits however, will be felt in the future and over very long time horizons.

- These benefits however might not be that high (from the current generation's perspective) to materialize the investment if the discount rate is high enough.

- So, a high discount rate could hinder the green transition and this could be bad for the environment, and thus, a low discount rate would be preferable.

Non-renewables extraction updates

- Due to energy security concerns in Europe, UK is looking to extract more oil and gas from reserves in the North Sea (see the link below for a report).

- What does this mean for the selection of the discount rate?

- It means that the depletion of these mature reserves will be accelerated and this implies that more emphasis is given to the present will ignoring the future. In turn, this implies a high discount rate for the extraction path of these resources. So, this time a high discount rate could be preferred but it is political situations that push for this choice.

https://www.ft.com/content/3c958f6b-2f71-4a86-97eb-97c71434df1d

- For more details see the comprehensive guidelines of the US Environmental Protection Agency (EPA), the Green Book by UK Treasury (also the guidelines from the Australian government).

- These documents present different techniques in a comprehensive way and approaches about dealing with policy issues, evaluation and appraisal techniques.

- They could be very useful to understand important real-world applications and they have a clear policy perspective.
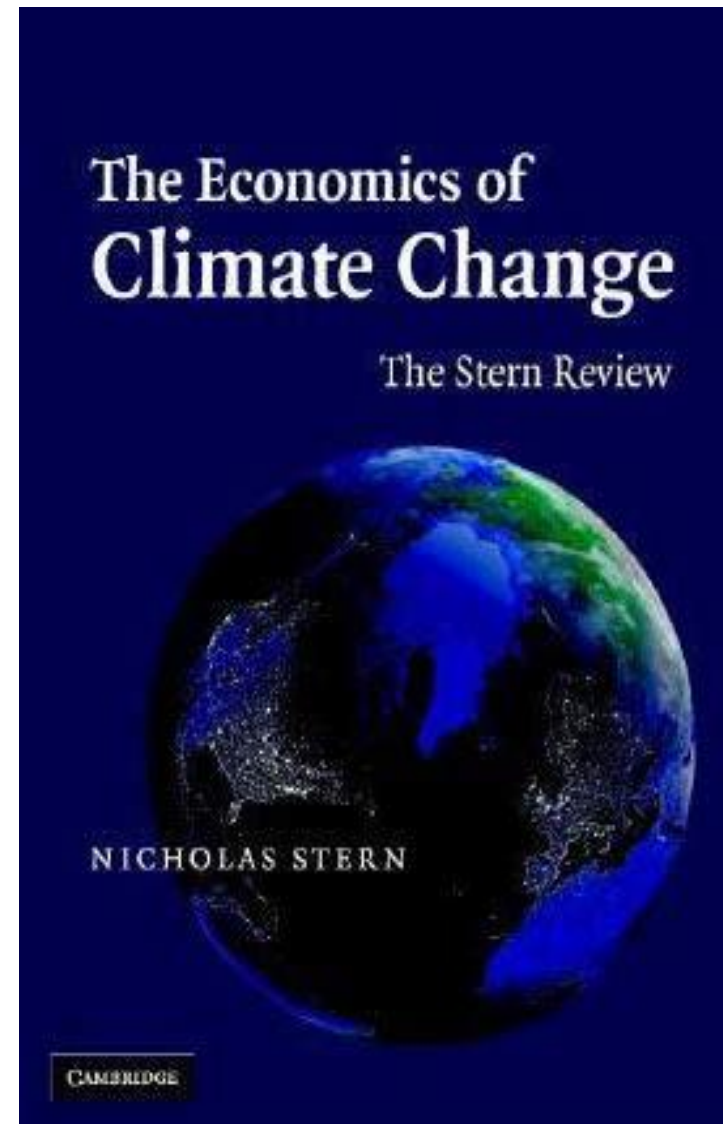
The Stern Review

- A very important issue with long-term implications is climate change.

- A pioneering report, although not the first one, on climate change was the Stern Review produced by the UK Treasury in late 2006.

- Although the report helped in the emphasis on the fight against climate change, prominent environmental economists have harshly criticized it (Weitzman, 2007; Nordhaus, 2007).

- Nordhaus (2007, p. 688): "First, the Review should be read primarily as a document that is political in nature and has advocacy as its purpose."

- Weitzman (2007, p. 723): "The Stern Review is a political document— in Keynes's phrase an essay in persuasion".

The Lord Stern of Brentford (Nicholas Stern)

- But what is at the heart of this criticism?

- The Stern Review has been criticized for choosing a single and very low discount rate, at approximately 1.4%. This contradicts the UK Treasury analysis as mentioned earlier.

- William Nordhaus (2007) claims that a close to zero discount rate does not contribute to our understanding about global warming.

- Martin Weitzman (2007) points that we are not really sure how to discount climate change.

William Nordhaus
Nobel Laureate, 2018

Creator of DICE (Dynamic Integrated Climate-Economy models) and RICE (Regional Climate-Economy model)
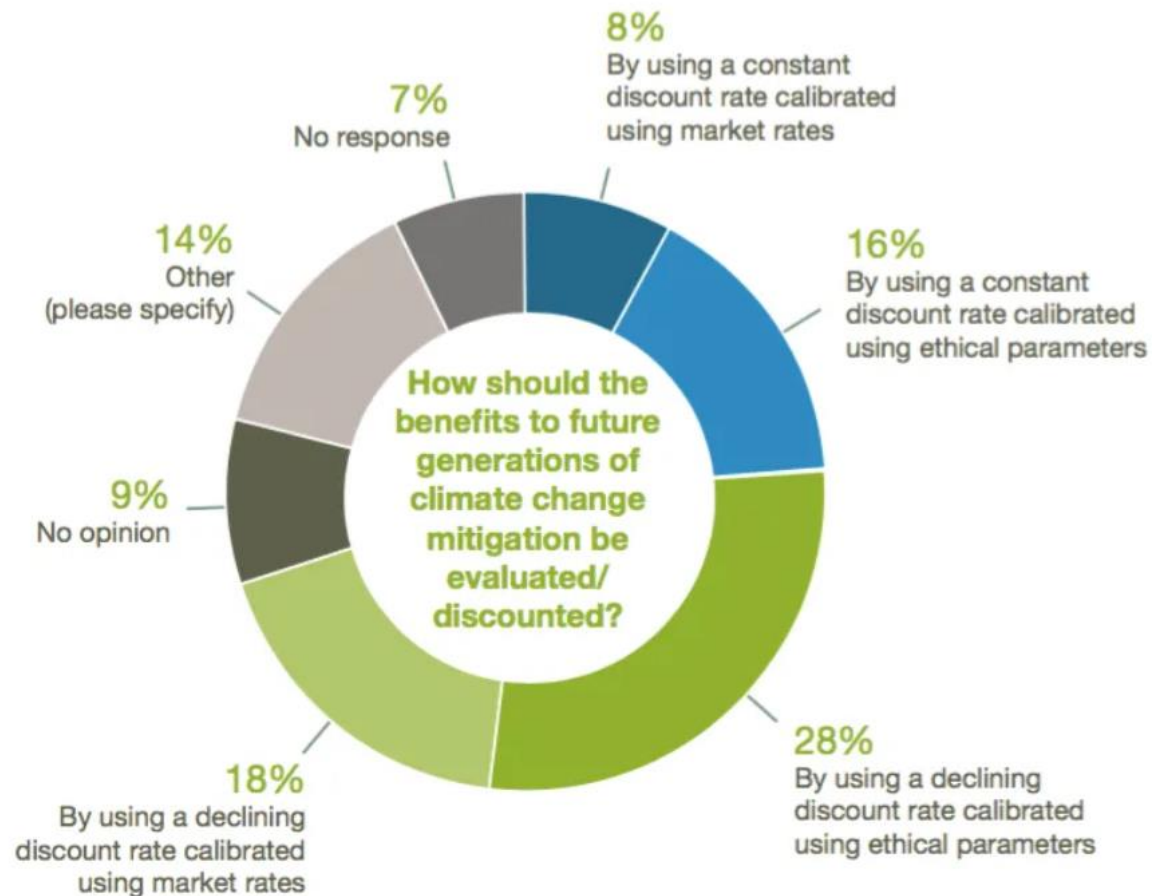
Uncertainty and long-term horizon

- What about the role of uncertainty in long-term horizon discounting problems?

- Given the difficulties in accurately quantifying uncertainty, this is not an easy question to answer.

- Generally, the additional uncertainty due to the long term horizon has been shown to affect negatively the discount rates (that is, discount rates drop in value).

- The step functions we discussed earlier is an attempt to account for uncertainty during the discounting process.

What economists think about discounting and climate change?

- In a survey in 2016, economist who work on climate change were asked about discount rate choice.

- Many support a declining discount rate (46%) and in addition many (44%) invoke ethical parameters for their choice.

How should the benefits to future generations of climate change mitigation be evaluated/discounted?

- 8% By using a constant discount rate calibrated using market rates
- 7% No response
- 14% Other (please specify)
- 16% By using a constant discount rate calibrated using ethical parameters
- 9% No opinion
- 28% By using a declining discount rate calibrated using ethical parameters
- 18% By using a declining discount rate calibrated using market rates

Time discounting in the ozone layer depletion problem

We have seen how time discounting could be a problem in the successful fight against climate change.

But there might be another important environmental problem where time discounting could have played a role in its solution. The ozone layer depletion, was a big problem back in 1980s but the Montreal Protocol (1987) was a successful international agreement to solve the problem.

Susan Solomon, an MIT professor says that one of the reasons for tackling the problem is "the clear and present danger the ozone hole posed to human health made it personal to people". In other words, the urgency of the problem was cancelling any attempts to discount it.

https://www.bbc.com/future/article/20220321-what-happened-to-the-worlds-ozone-hole

THE FUTURE
DEPENDS ON
WHAT WE DO IN
THE PRESENT.

MAHATMA GANDHI

- Intertemporal choice could be more important than what you might think.

- It could have an impact on multiple and different aspects of your life.

There is an expert on intertemporal choice at the University of Warwick:

Professor Daniel Read

Professor of Behavioural Science

Behavioural Science Group, Global Energy Research Network

Warwick Business School

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