Lecture 09

Discounting and Cost Benefit Analysis

Ivan Rudik
AEM 4510

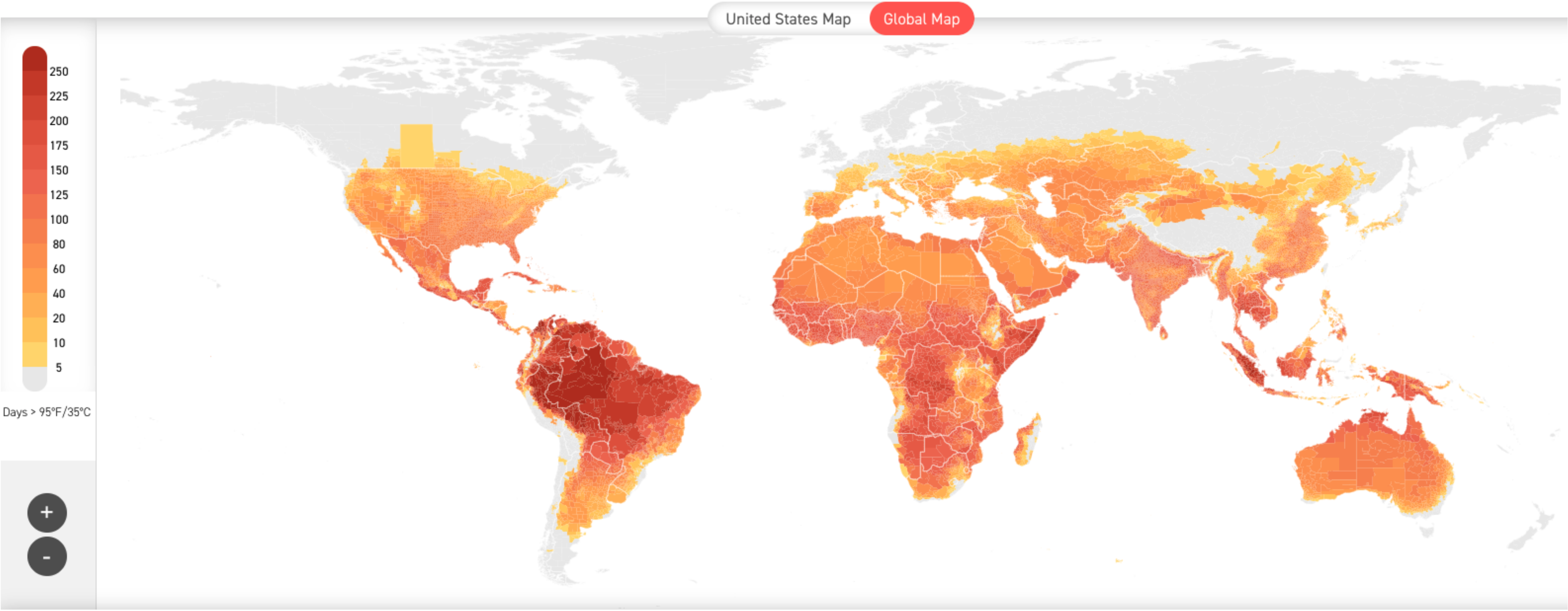
Roadmap

1. What is discounting?
2. What determines the discount rate?
3. What are the implications of discounting on computing the costs and benefits of policies?

Discounting

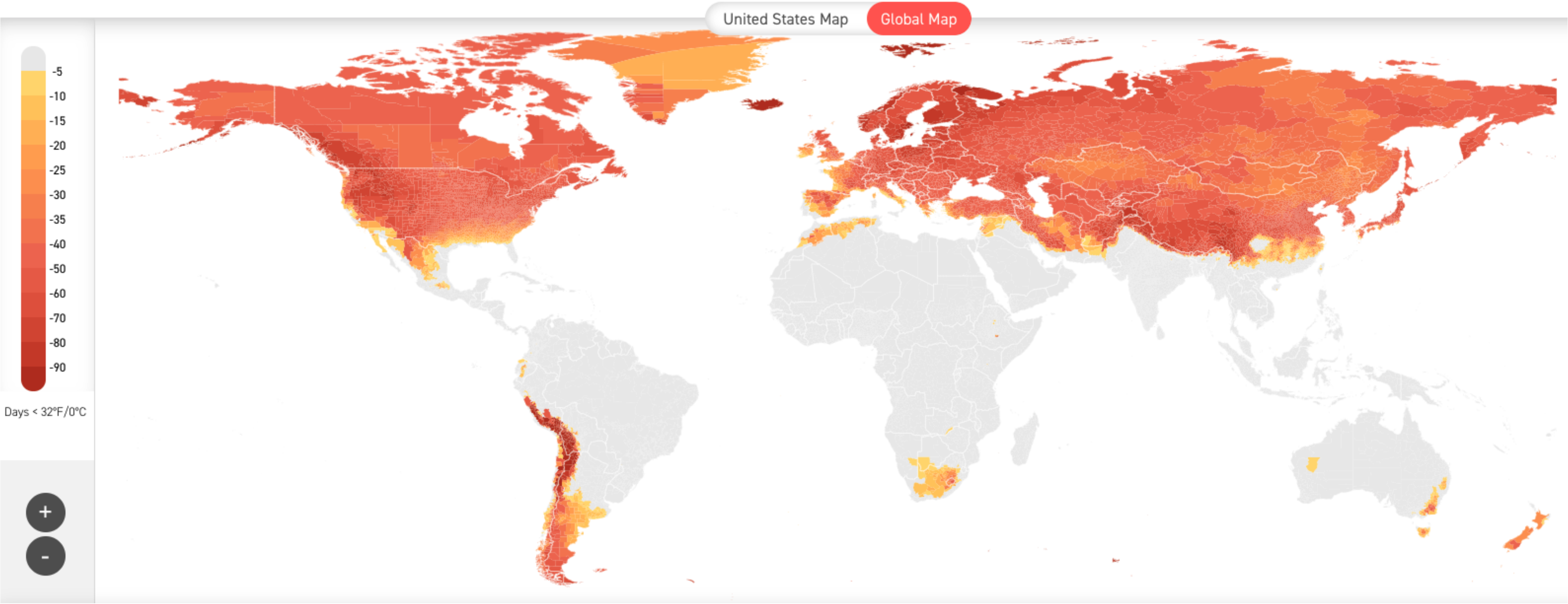
Motivating discounting: http://impactlab.org/map

At the end of the century we will have much more hot days in some places



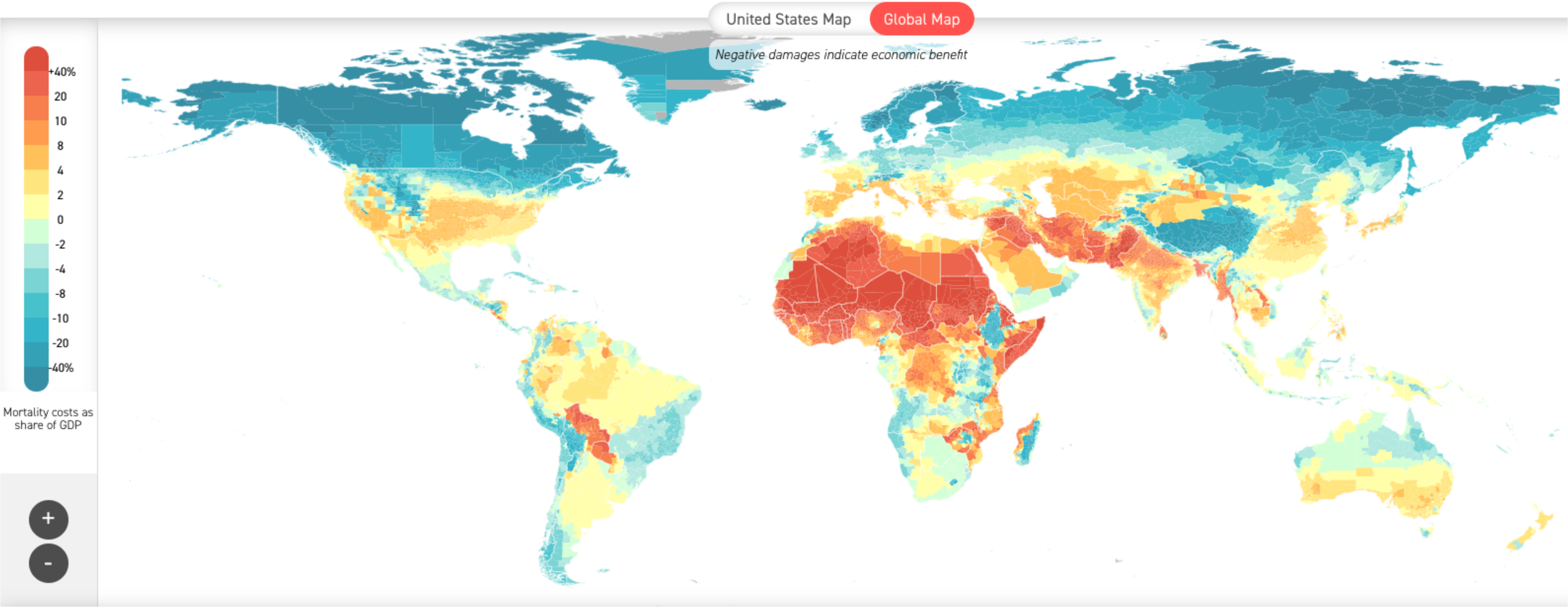
Motivating discounting: http://impactlab.org/map

At the end of the century we will have much fewer freezing days in others



Motivating discounting: http://impactlab.org/map

This has massive implications for mortality



Motivating discounting

Some places are expecting to have huge gains in GDP from mortality risk

Motivating discounting

Some places are expecting to have huge gains in GDP from mortality risk

Others are expecting to have huge losses

Motivating discounting

Some places are expecting to have huge gains in GDP from mortality risk

Others are expecting to have huge losses

This is all happening in 60-80 years

Motivating discounting

Some places are expecting to have huge gains in GDP from mortality risk

Others are expecting to have huge losses

This is all happening in 60-80 years

How do we compare these costs and benefits to those incurred today?

Motivating discounting

Some places are expecting to have huge gains in GDP from mortality risk

Others are expecting to have huge losses

This is all happening in 60-80 years

How do we compare these costs and benefits to those incurred today?

We use a **discount rate:** a value that tells us how much future dollars are worth in today's terms

Return to Manne-Richels

We ignored the idea of discounting in our discussion of the Manne-Richels model

Return to Manne-Richels

We ignored the idea of discounting in our discussion of the Manne-Richels model

Let r be the discount rate, so $\beta = \frac{1}{1+r}$ is the discount factor

Return to Manne-Richels

We ignored the idea of discounting in our discussion of the Manne-Richels model

Let r be the discount rate, so $\beta = \frac{1}{1+r}$ is the discount factor

Our new problem with discounting is then:

Return to Manne-Richels

We ignored the idea of discounting in our discussion of the Manne-Richels model

Let r be the discount rate, so $\beta = \frac{1}{1+r}$ is the discount factor

Our new problem with discounting is then:

$$\min_{a_1} E[TC] = \underbrace{\frac{1}{2}a_1^2}_{\text{current cost}} + \beta\left[(1-p) \times \underbrace{0}_{\text{good state cost}} + p \times \underbrace{\frac{1}{2}(1-a_1)^2}_{\text{bad state cost}}\right]$$

Return to Manne-Richels

The first-order condition is:

$$\frac{dE[TC]}{da_1} = a_1^* - \beta p(1 - a_1^*) = 0$$

Return to Manne-Richels

The first-order condition is:

$$\frac{dE[TC]}{da_1} = a_1^* - \beta p(1 - a_1^*) = 0$$

This gives us that:

$$a_1^* = \frac{\beta p}{1 + \beta p}$$

Return to Manne-Richels

The first-order condition is:

$$\frac{dE[TC]}{da_1} = a_1^* - \beta p(1 - a_1^*) = 0$$

This gives us that:

$$a_1^* = \frac{\beta p}{1 + \beta p}$$

How does discounting affect our decisionmaking?

Discounting and decisionmaking

$$a_1^* = \frac{\beta p}{1 + \beta p}$$

Discounting and decisionmaking

$$a_1^* = \frac{\beta p}{1 + \beta p}$$

First, notice as $r \to \infty$ we have $\beta = \frac{1}{1+r} \to 0$, we put less and less weight on the future

Discounting and decisionmaking

$$a_1^* = \frac{\beta p}{1 + \beta p}$$

First, notice as $r \to \infty$ we have $\beta = \frac{1}{1+r} \to 0$, we put less and less weight on the future

This means we do less abatement today in period 1!

Discounting and decisionmaking

$$a_1^* = \frac{\beta p}{1 + \beta p}$$

First, notice as $r \rightarrow \infty$ we have $\beta = \frac{1}{1+r} \rightarrow 0$, we put less and less weight on the future

This means we do less abatement today in period 1!

That's intuitive, let's see what discount actually looks like graphically

Discounting and decisionmaking

$$a_1^* = \frac{\beta p}{1 + \beta p}$$

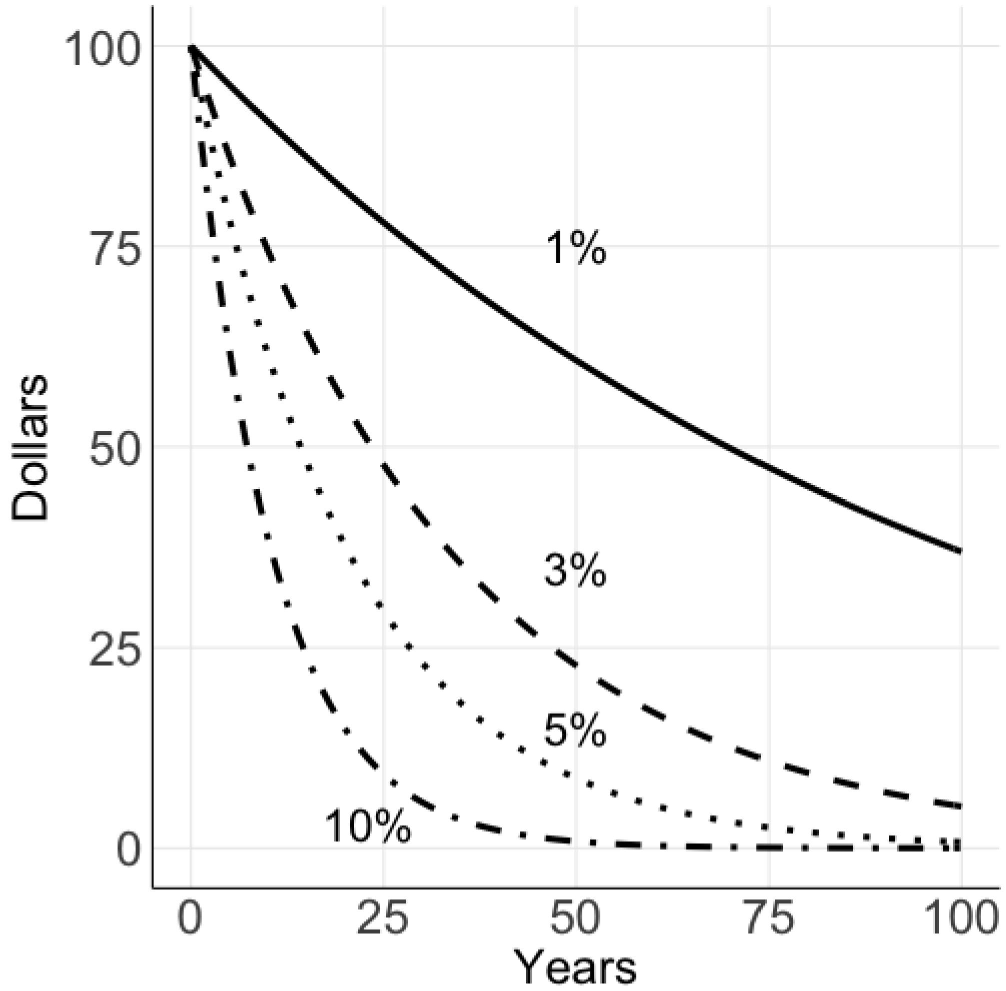
First, notice as $r \to \infty$ we have $\beta = \frac{1}{1+r} \to 0$, we put less and less weight on the future

This means we do less abatement today in period 1!

That's intuitive, let's see what discount actually looks like graphically

What is the value of a future payment of $100?

PV of $100



Higher discount rates place less value on future benefits

Things > 30 years in the future have basically no value with a 10% discount rate

At a 1% discount rate we value things 100 years in the future at almost half their value today

Discounting

Why does this matter?

Discounting

Why does this matter?

Lots of things (like climate change) have costs or benefits that occur **far** in the future

Discounting

Why does this matter?

Lots of things (like climate change) have costs or benefits that occur **far** in the future

e.g. the benefits of taking action against climate change will be mostly borne by future generations, decades from now

Discounting

Why does this matter?

Lots of things (like climate change) have costs or benefits that occur **far** in the future

e.g. the benefits of taking action against climate change will be mostly borne by future generations, decades from now

Depending on our choice of discount rate these costs and benefits can be substantial or trivial

Discounting

1 million in damages in 200 years at a discount rate of r = 2% is worth 19,053 today

Discounting

1 million in damages in 200 years at a discount rate of r = 2% is worth 19,053 today

1 million in damages in 200 years at a discount rate of r = 8% is worth only 21 cents today

Discounting

1 million in damages in 200 years at a discount rate of r = 2% is worth 19,053 today

1 million in damages in 200 years at a discount rate of r = 8% is worth only 21 cents today

5 orders of magnitude difference!

Discounting

1 million in damages in 200 years at a discount rate of r = 2% is worth 19,053 today

1 million in damages in 200 years at a discount rate of r = 8% is worth only 21 cents today

5 orders of magnitude difference!

This makes the choice of the discount rate one of the most important (and contentious) things about climate change policy

Discounting: how do we choose?

How do we choose the discount rate?

Discounting: how do we choose?

How do we choose the discount rate?

Option 1: take the market rate

Discounting: how do we choose?

How do we choose the discount rate?

Option 1: take the market rate

This is just the real interest paid on certain investments

Discounting: how do we choose?

How do we choose the discount rate?

Option 1: take the market rate

This is just the real interest paid on certain investments

In a perfect market equilibrium, it is the productivity of capital

Discounting: how do we choose?

How do we choose the discount rate?

Option 1: take the market rate

This is just the real interest paid on certain investments

In a perfect market equilibrium, it is the productivity of capital

Why might this not be the rate we want to choose as a regulator?

Discounting: how do we choose?

Issues with market rates:

Discounting: how do we choose?

Issues with market rates:

Market rates don't reflect externalities

Discounting: how do we choose?

Issues with market rates:

Market rates don't reflect externalities

Super-responsibility of government: the government represents future generations as well as current generations (only current ones are represented in the market)

Discounting: how do we choose?

Issues with market rates:

Market rates don't reflect externalities

Super-responsibility of government: the government represents future generations as well as current generations (only current ones are represented in the market)

Dual-role of individuals: in political roles, people are more concerned about future generations than in their day-to-day behavior which determines the market rate

Discounting: how do we choose?

Option 2: social discounting

Discounting: how do we choose?

Option 2: social discounting

With social discounting with determine the discount rate from economic and ethical considerations

Discounting: how do we choose?

Option 2: social discounting

With social discounting with determine the discount rate from economic and ethical considerations

Why should we discount the future?

Discounting: how do we choose?

Option 2: social discounting

With social discounting with determine the discount rate from economic and ethical considerations

Why should we discount the future?

First, time: people are impatient

Discounting: how do we choose?

Option 2: social discounting

With social discounting with determine the discount rate from economic and ethical considerations

Why should we discount the future?

First, time: people are impatient

And growth: if someone is richer in 10 years, a dollar is worth more to them today than in 10 years in utility terms

Ramsey Discounting

With a decent amount of math we can show that the social discount rate r is composed of three terms:

$$r = \delta + \eta \times g$$

Ramsey Discounting

With a decent amount of math we can show that the social discount rate r is composed of three terms:

$$r = \delta + \eta \times g$$

δ is called the **pure rate of time preference** or **utility discount rate**: how much do we value future *utility*

Ramsey Discounting

With a decent amount of math we can show that the social discount rate r is composed of three terms:

$$r = \delta + \eta \times g$$

δ is called the **pure rate of time preference** or **utility discount rate**: how much do we value future *utility*

η is the **elasticity of marginal utility**: how quickly does marginal utility decline in consumption?

Ramsey Discounting

With a decent amount of math we can show that the social discount rate r is composed of three terms:

$$r = \delta + \eta \times g$$

δ is called the **pure rate of time preference** or **utility discount rate**: how much do we value future *utility*

η is the **elasticity of marginal utility**: how quickly does marginal utility decline in consumption?

g is the **growth rate**: how fast does consumption grow over time?

Ramsey Discounting

Here's some alternative descriptions of how to think about these terms:

Ramsey Discounting

Here's some alternative descriptions of how to think about these terms:

δ: how much is 1 util tomorrow worth today?

Ramsey Discounting

Here's some alternative descriptions of how to think about these terms:

δ: how much is 1 util tomorrow worth today?

η: how much do we value poorer vs richer times/generations? Bigger $\eta \rightarrow$ more averse to inequality over time

- $\eta = -\frac{U''(X)X}{U'(X)}$, how many percent does MU change if consumption changes by 1%

Ramsey Discounting

Here's some alternative descriptions of how to think about these terms:

δ: how much is 1 util tomorrow worth today?

η: how much do we value poorer vs richer times/generations? Bigger $\eta \to$ more averse to inequality over time

- $\eta = -\frac{U''(X)X}{U'(X)}$, how many percent does MU change if consumption changes by 1%

g: how rich will we / future generations be compared to today?

Ramsey Discounting

$$r = \delta + \eta \times g$$

What this means is that if we have values for r, η, and g, we can compute the "correct" discount rate

Ramsey Discounting

$$r = \delta + \eta \times g$$

What this means is that if we have values for r, η, and g, we can compute the "correct" discount rate

How do we get values for these terms?

Ramsey Discounting

$$r = \delta + \eta \times g$$

What this means is that if we have values for r, η, and g, we can compute the "correct" discount rate

How do we get values for these terms?

Two common approaches: descriptive and prescriptive

Ramsey Discounting: the descriptive approach

The descriptive approach aims to calibrate the discount rate to the real world

Ramsey Discounting: the descriptive approach

The descriptive approach aims to calibrate the discount rate to the real world

We can observe g in the data / forecasts

Ramsey Discounting: the descriptive approach

The descriptive approach aims to calibrate the discount rate to the real world

We can observe g in the data / forecasts

We can sometimes estimate η from observed behavior over time

Ramsey Discounting: the descriptive approach

The descriptive approach aims to calibrate the discount rate to the real world

We can observe g in the data / forecasts

We can sometimes estimate η from observed behavior over time

Once we pick a δ we have our discount rate r

Ramsey Discounting: the descriptive approach

The descriptive approach aims to calibrate the discount rate to the real world

We can observe g in the data / forecasts

We can sometimes estimate η from observed behavior over time

Once we pick a δ we have our discount rate r

The descriptive approach generally chooses δ so r matches market rates

Ramsey Discounting: the prescriptive approach

First we decide on the 'correct' level of δ and η

Ramsey Discounting: the prescriptive approach

First we decide on the 'correct' level of δ and η

Then we observe g in the data / forecasts

Ramsey Discounting: the prescriptive approach

First we decide on the 'correct' level of δ and η

Then we observe g in the data / forecasts

That gives us r

What's the utility discount rate?

Both approaches depend on us choosing δ

What's the utility discount rate?

Both approaches depend on us choosing δ

What is the right value for δ?

What's the utility discount rate?

Both approaches depend on us choosing δ

What is the right value for δ?

Ramsey (1928): placing different weights upon the utility of different generations is ‘ethically indefensible'

What's the utility discount rate?

Both approaches depend on us choosing δ

What is the right value for δ?

Ramsey (1928): placing different weights upon the utility of different generations is ‘ethically indefensible'

Harrod (1948): discounting utility represented a 'polite expression for rapacity and the conquest of reason by passion'

What's the utility discount rate?

Both approaches depend on us choosing δ

What is the right value for δ?

Ramsey (1928): placing different weights upon the utility of different generations is ‘ethically indefensible'

Harrod (1948): discounting utility represented a 'polite expression for rapacity and the conquest of reason by passion'

The above arguments are ethical arguments, so are typically used by those favoring the prescriptive approach

What's the discount rate? Descriptive

The descriptive approach often results in δ being between 2-3% from reverse engineering the observed market rates

What's the discount rate? Descriptive

The descriptive approach often results in δ being between 2-3% from reverse engineering the observed market rates

η is then often engineered to be between 1 and 4

What's the discount rate? Descriptive

The descriptive approach often results in δ being between 2-3% from reverse engineering the observed market rates

η is then often engineered to be between 1 and 4

g is observed and generally between 1 and 3%

What's the discount rate? Descriptive

The descriptive approach often results in δ being between 2-3% from reverse engineering the observed market rates

η is then often engineered to be between 1 and 4

g is observed and generally between 1 and 3%

Thus the discount rate usually lies between 2 and 7%

What's the discount rate? Descriptive

The descriptive approach often results in δ being between 2-3% from reverse engineering the observed market rates

η is then often engineered to be between 1 and 4

g is observed and generally between 1 and 3%

Thus the discount rate usually lies between 2 and 7%

Quick example: $\delta = 2\%, \eta = 2, g = 2\% \rightarrow r = 6\%$

What's the discount rate? Prescriptive

The prescriptive approach often results in δ being zero or nearly zero for the ethical reasons described above

What's the discount rate? Prescriptive

Choosing η also conveys ethical choices: how do we weigh the distribution of consumption across generations

What's the discount rate? Prescriptive

Choosing η also conveys ethical choices: how do we weigh the distribution of consumption across generations

What's the discount rate? Prescriptive

Choosing η also conveys ethical choices: how do we weigh the distribution of consumption across generations

- $\eta = 0$: consumption in the future doesn't change our willingness to save/invest today (r is independent of g)

What's the discount rate? Prescriptive

Choosing η also conveys ethical choices: how do we weigh the distribution of consumption across generations

- $\eta = 0$: consumption in the future doesn't change our willingness to save/invest today (r is independent of g)
- η is large: if there is positive growth, we are **less** likely to invest in the future (future generations will be rich anyway)

What's the discount rate? Prescriptive

Choosing η also conveys ethical choices: how do we weigh the distribution of consumption across generations

- $\eta = 0$: consumption in the future doesn't change our willingness to save/invest today (r is independent of g)

- η is large: if there is positive growth, we are **less** likely to invest in the future (future generations will be rich anyway)

- η is large: if there is negative growth, we are **more** likely to invest in the future (future generations will be poorer than today)

Distributive justice

Rawl's theory of justice applied here would set $\delta = 0$ and $\eta = \infty$: fairness for all

Distributive justice

Rawl's theory of justice applied here would set $\delta = 0$ and $\eta = \infty$: fairness for all

More egalitarian perspectives with respect to:

time

Distributive justice

Rawl's theory of justice applied here would set $\delta = 0$ and $\eta = \infty$: fairness for all

More egalitarian perspectives with respect to:

time yields a smaller δ and r

Distributive justice

Rawl's theory of justice applied here would set $\delta = 0$ and $\eta = \infty$: fairness for all

More egalitarian perspectives with respect to:

time yields a smaller δ and r

intergenerational inequality

Distributive justice

Rawl's theory of justice applied here would set $\delta = 0$ and $\eta = \infty$: fairness for all

More egalitarian perspectives with respect to:

time yields a smaller δ and r

intergenerational inequality yields a larger η and larger r if growth is positive

What do the experts think? Weitzman (2001)