Lecture 09

Discounting and Cost Benefit Analysis

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AEM 4510

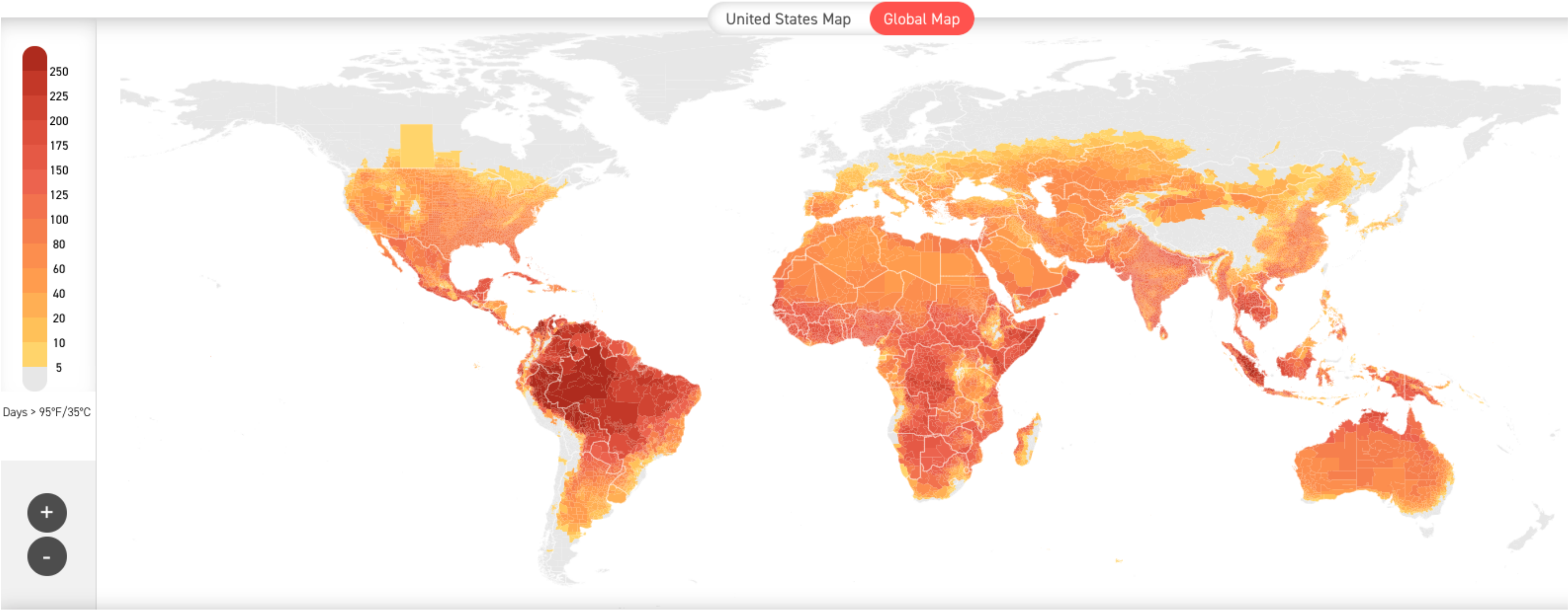
Roadmap

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



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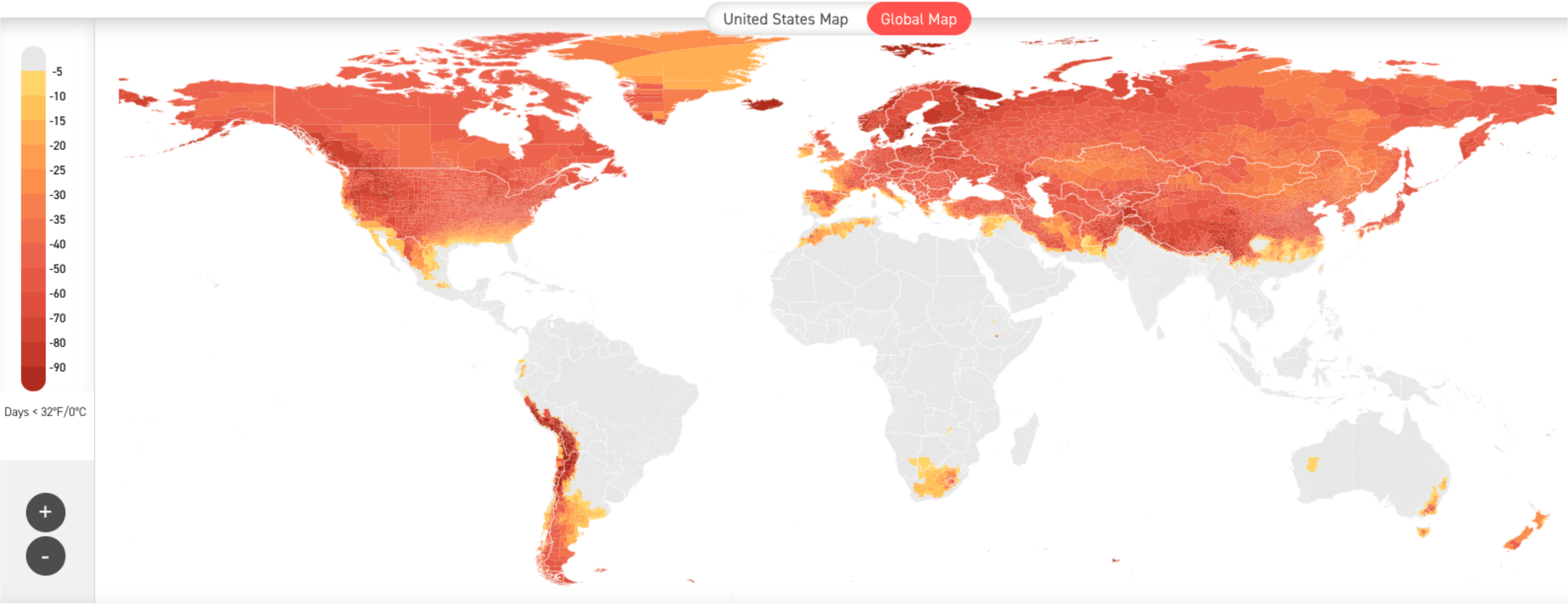
At the end of the century we will have much fewer freezing days in others



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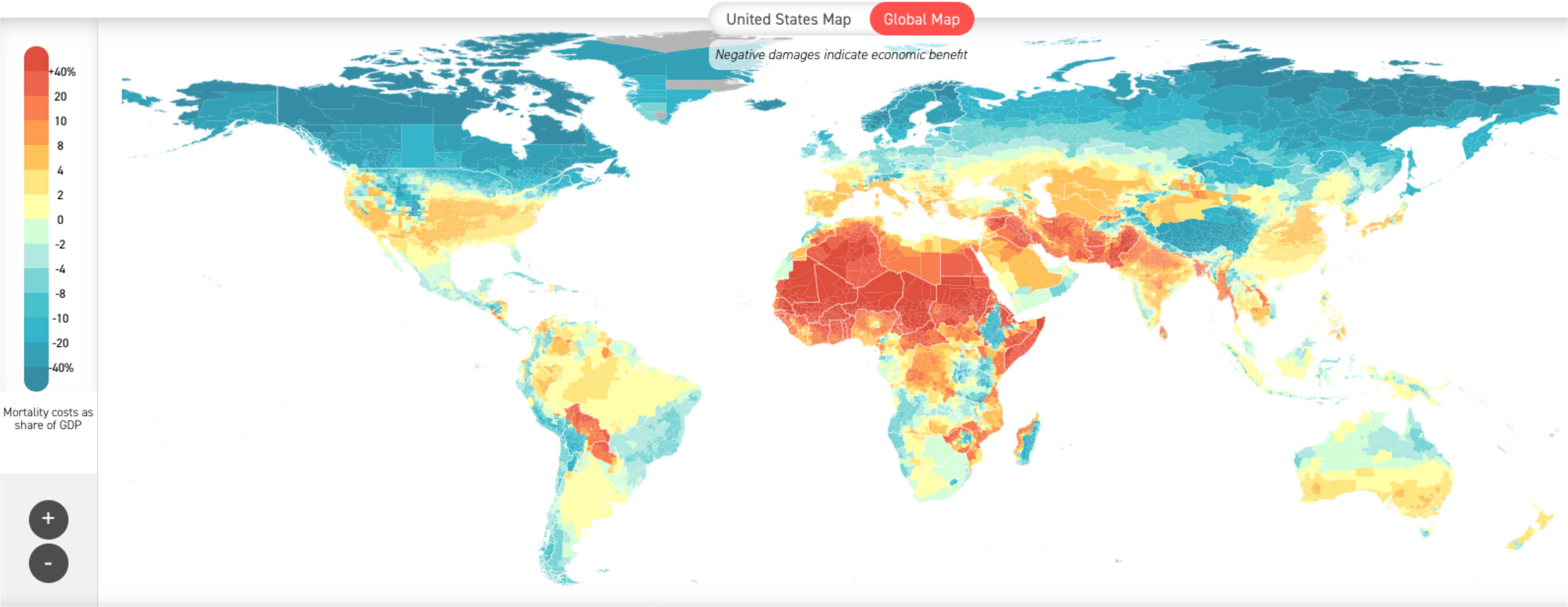
This has massive implications for mortality



Motivating discounting

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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

A simple example

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

Suppose we are considering two different projects that have costs and benefits that accrue differently over time

Year	Project A Cost	Project A Benefit	Project B Cost	Project B Benefit
0	10000	0	6000	0
1	1000	4000	0	1000
2	0	4000	0	3000
3	0	4000	0	3000

Project A has higher costs and benefits in nominal terms

A simple example

Year	Project A Cost	Project A Benefit	Project B Cost	Project B Benefit
0	10000	0	6000	0
1	1000	4000	0	1000
2	0	4000	0	3000
3	0	4000	0	3000

Project A:

$$PV_A = \frac{4000}{1.05^1} + \frac{4000}{1.05^2} + \frac{4000}{1.05^3} - \frac{10000}{1.05^0} - \frac{1000}{1.05^1} = 1791.76$$

Project B:

$$PV_B = \frac{1000}{1.05^1} + \frac{3000}{1.05^2} + \frac{3000}{1.05^3} - \frac{6000}{1.05^0} = 1648.09$$

What if the discount rate was 3%?

Year	Project A Cost	Project A Benefit	Project B Cost	Project B Benefit
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Project A:

$$PV_A = \frac{4000}{1.03^1} + \frac{4000}{1.03^2} + \frac{4000}{1.03^3} - \frac{10000}{1.03^0} - \frac{1000}{1.03^1} = 2262.35$$

Project B:

$$PV_B = \frac{1000}{1.03^1} + \frac{3000}{1.03^2} + \frac{3000}{1.03^3} - \frac{6000}{1.03^0} = 2144.69$$

Discounting

Discounting results in us placing less value on costs and benefits that accrue in the future

A dollar 1 year from now is worth $\beta = \frac{1}{1+r}$ dollars today

The timing of costs and benefits of projects can then sway which project has greater present value

Return to Manne-Richels

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

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Our new problem with discounting is then:

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

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The first-order condition is:

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

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How does discounting affect our decisionmaking?

Discounting and decisionmaking

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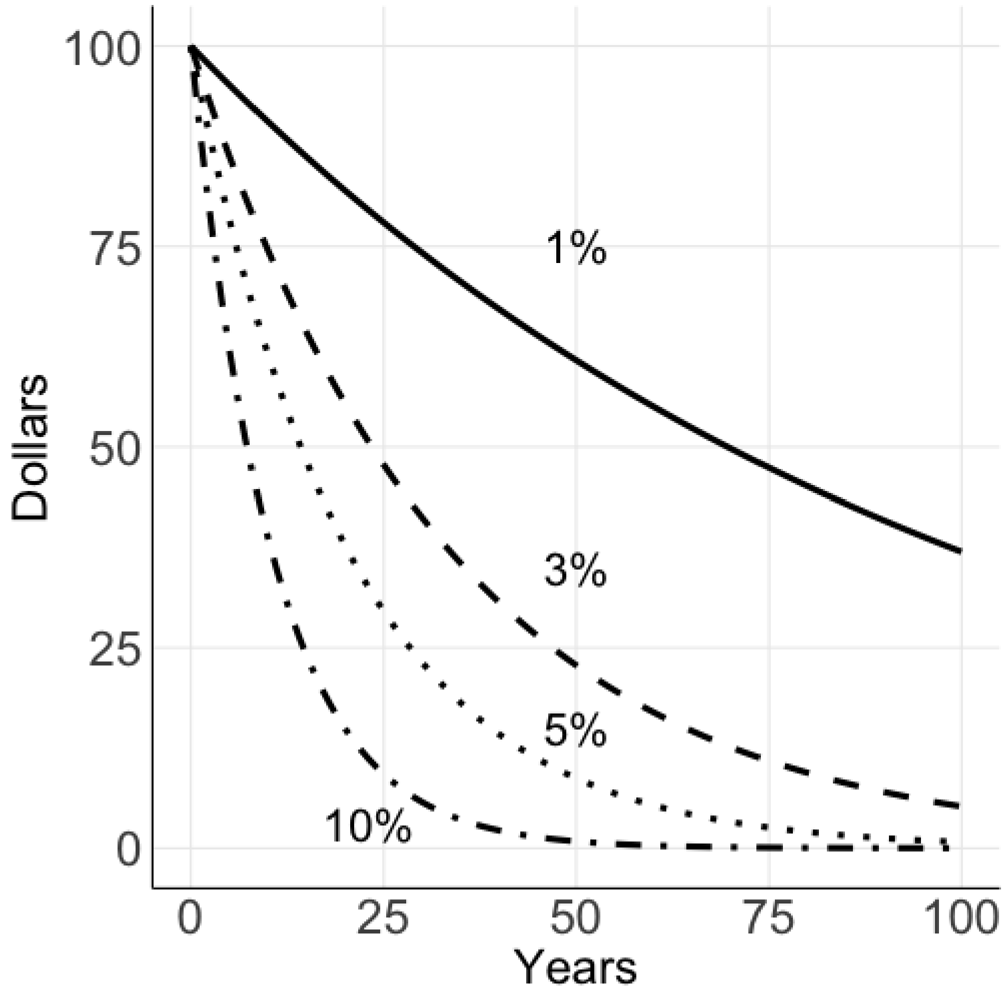
What is the value of a future payment of $100?

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

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

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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?

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

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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

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Why should we discount the future?

First, **time**: people are impatient

And **growth/inequality**: all else equal, if someone is richer in 10 years, a dollar is worth more to them today than in 10 years (in utility terms)

Ramsey Discounting

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

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

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

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

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

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How do we get values for these terms?

Two common approaches: descriptive and prescriptive

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Most philosophers and economists would probably not prescribe the descriptive approach

Ramsey Discounting: the prescriptive approach

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

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That gives us r

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

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g is observed and generally between 1 and 3%

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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

Recall: $r = \delta + \eta g$

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Recall: $r = \delta + \eta g$

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

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- $\eta = 0$: 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

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

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More egalitarian perspectives with respect to:

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intergenerational inequality

Distributive justice

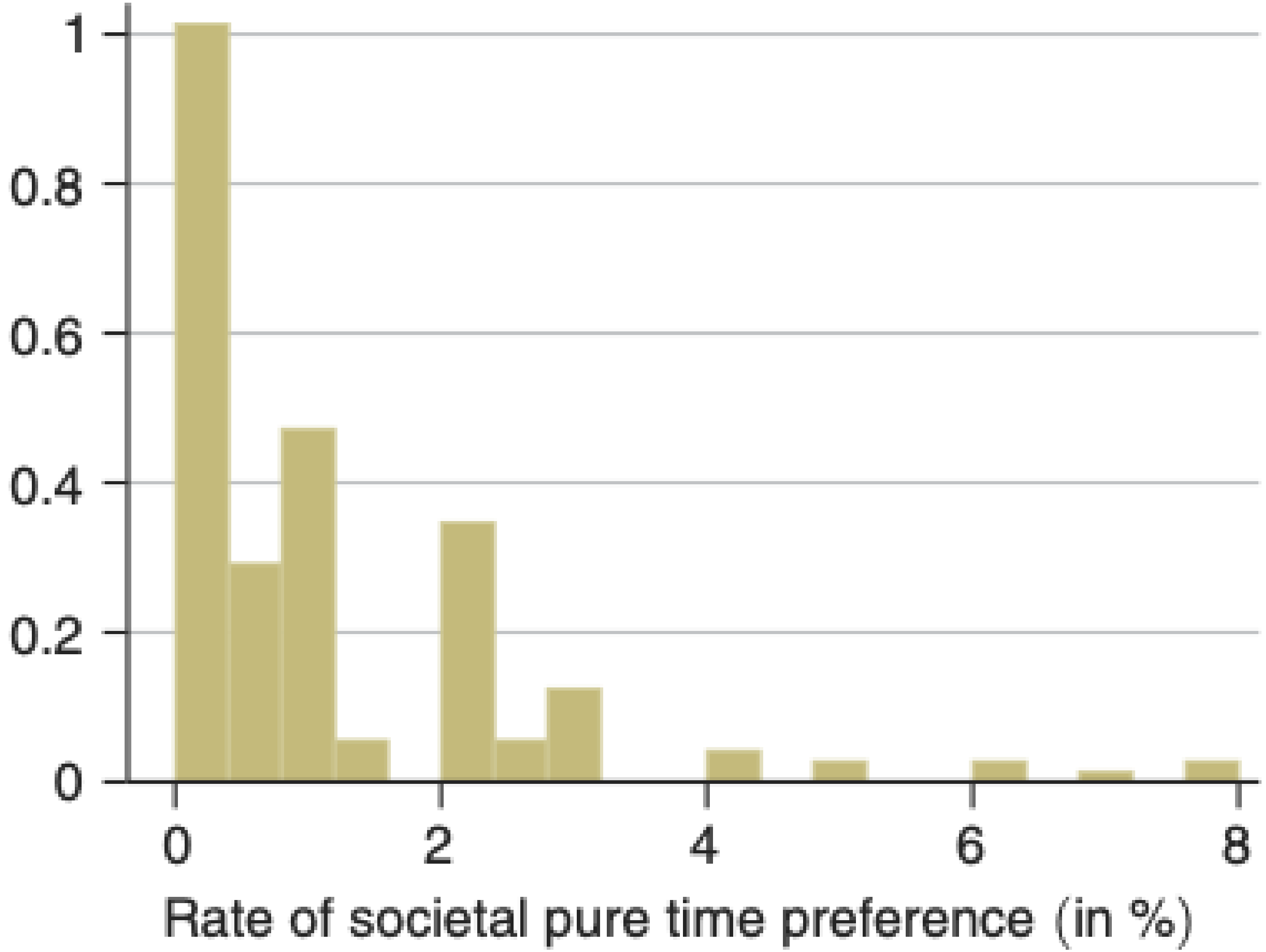
Rawls' theory of justice applied here would set $\delta = 0$ and $\eta = \infty$: fairness for all

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? Drupp et al. (2018)



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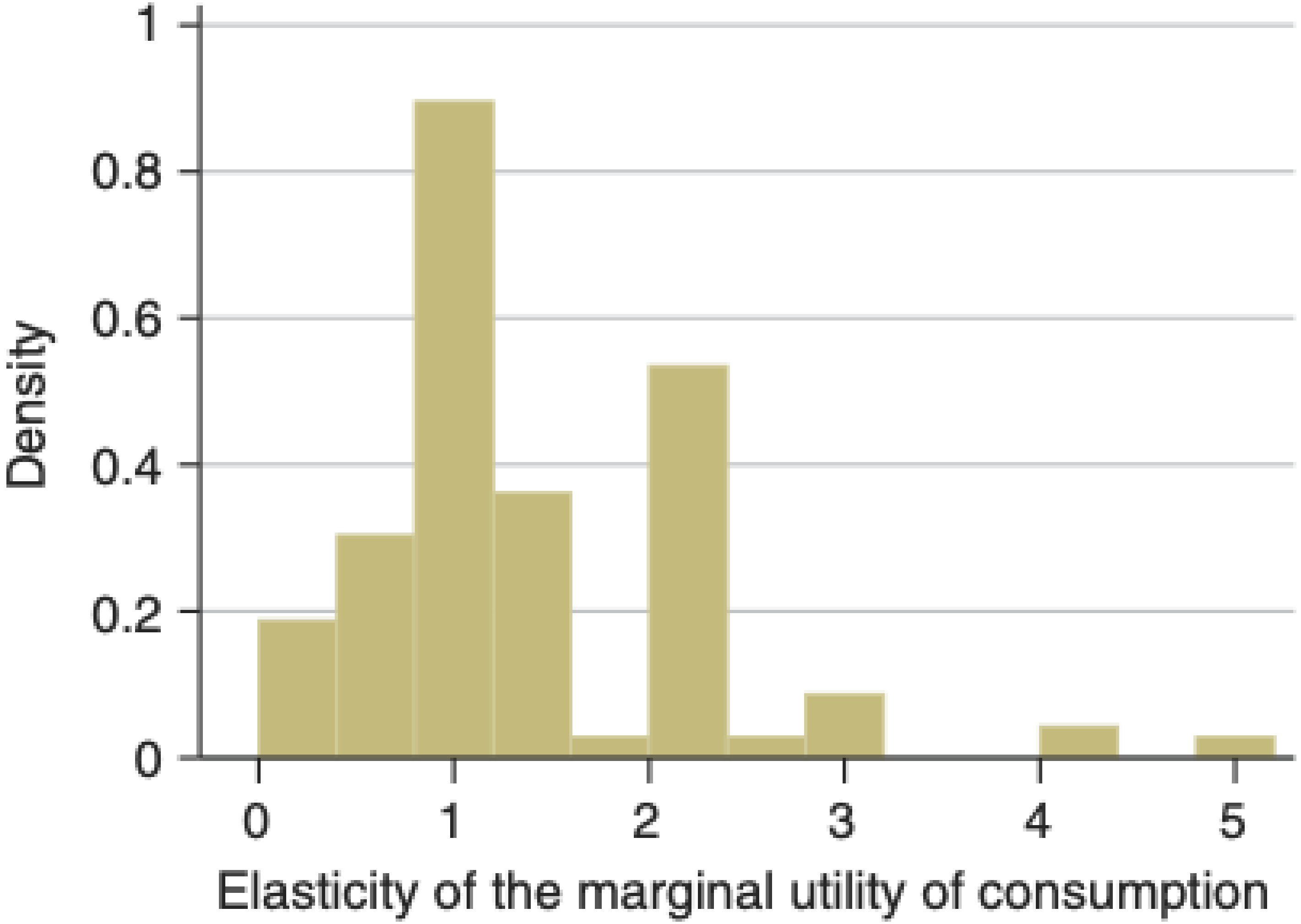

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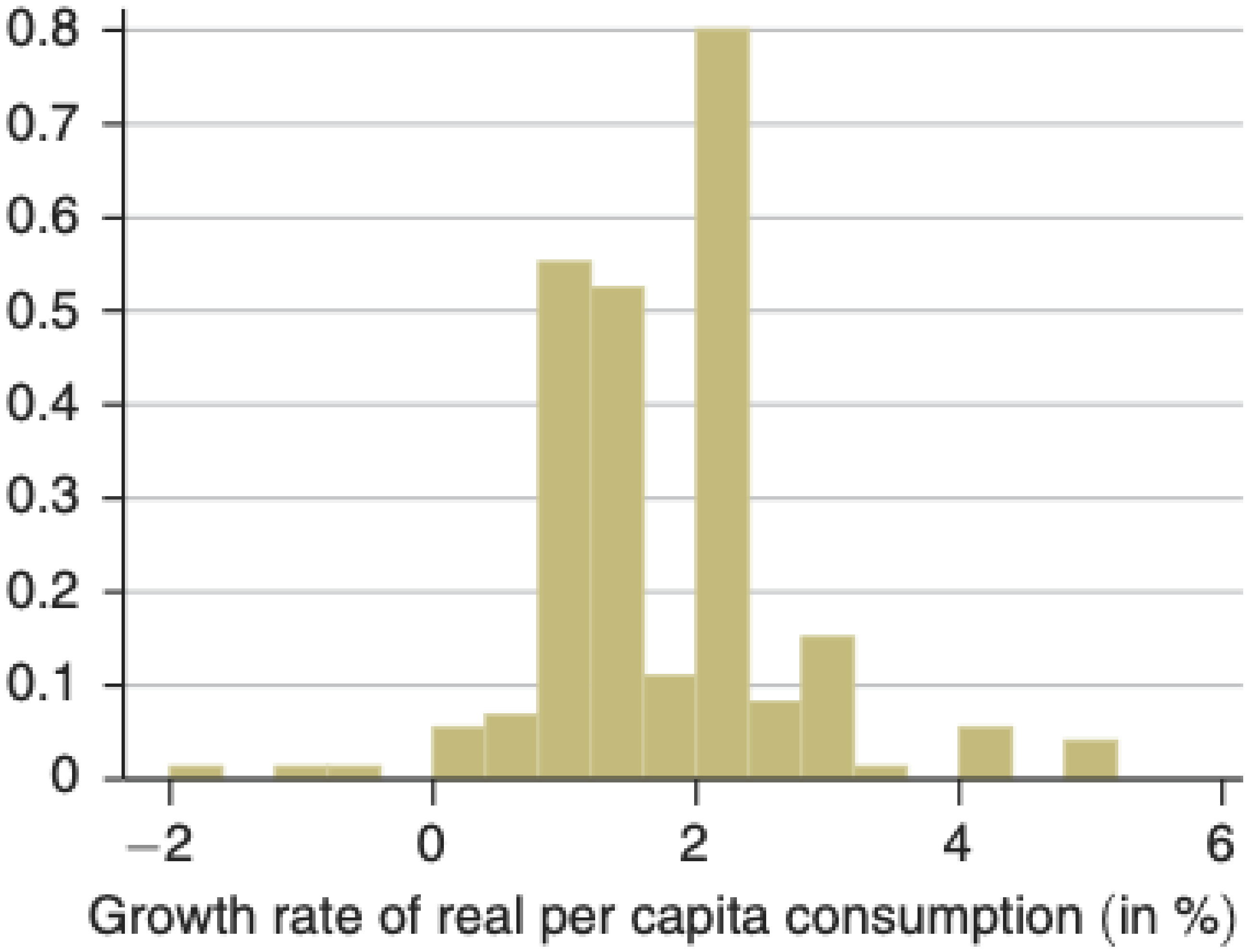

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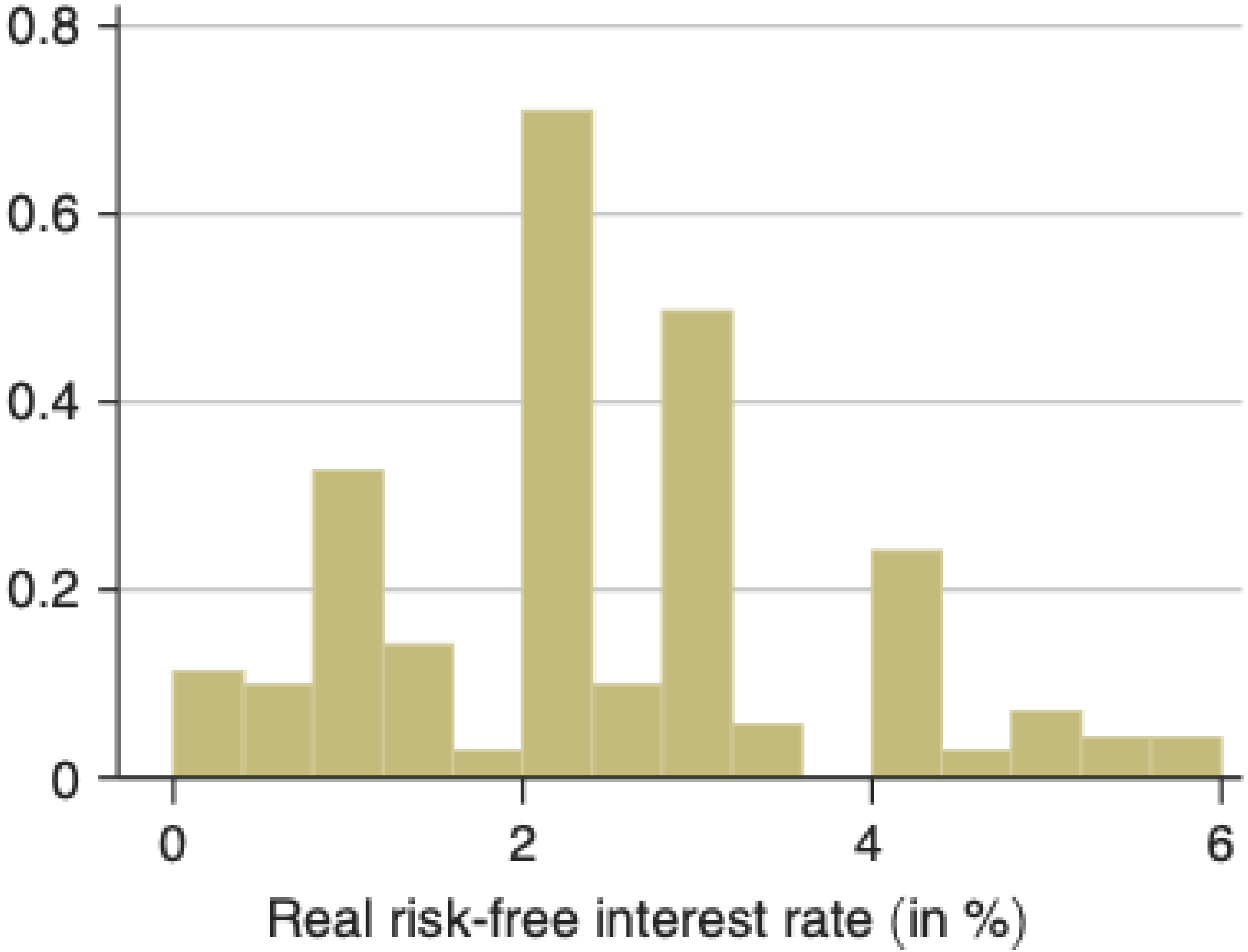

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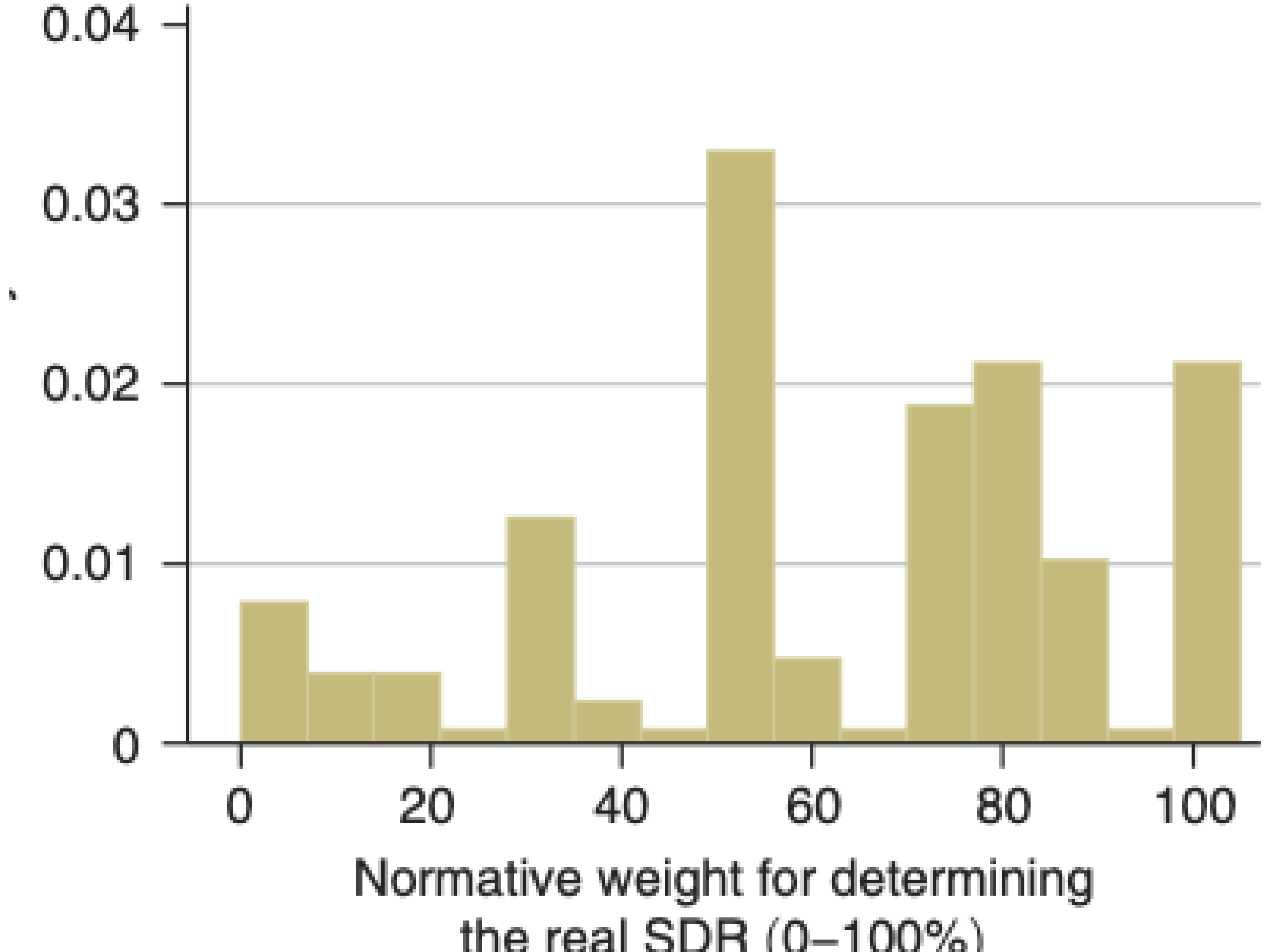

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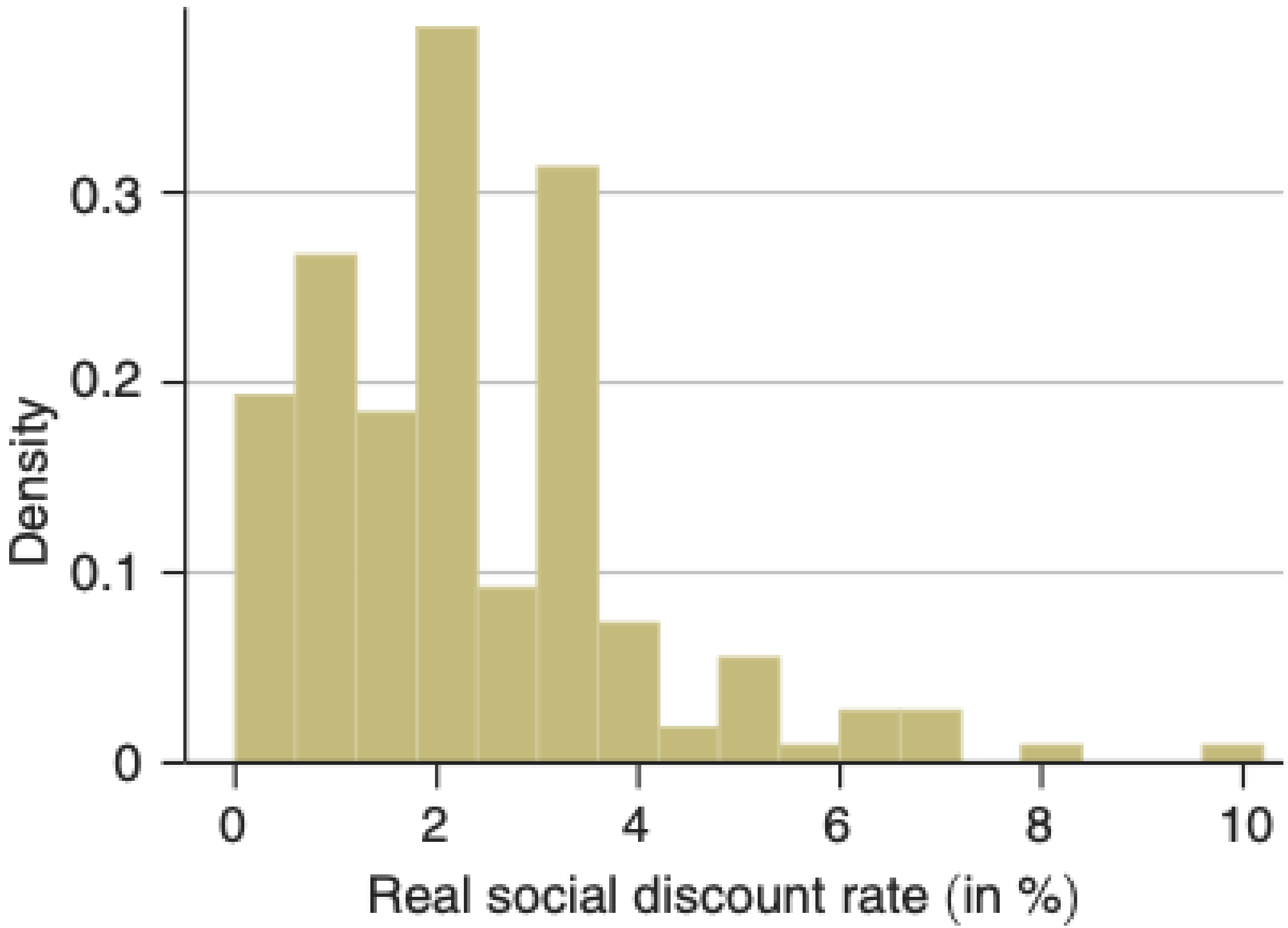

Discount rates are being significantly revised

Council of Economic Advisers
@WhiteHouseCEA

Today, OMB released an important proposed update to Circular A-4, guidance that Federal agencies use to analyze the benefits and costs of proposed Federal regulations. It has not been updated since it was first issued in 2003. 1/

Discount rates are being significantly revised

Council of Economic Advisers @WhiteHouseCEA · 17h

Replying to @WhiteHouseCEA

Federal regulations affect issues ranging from environmental protection, to workplace safety, to education, to health. Newly proposed regulations may have billions of dollars in economic impacts in a given year. 2/

2 3 10 1,575

Council of Economic Advisers @WhiteHouseCEA · 17h

In the 20 years since Circular A-4 was issued, economic conditions and best practices for benefit-cost analysis have evolved, and updating the Circular will make it easier to promote regulations that most enhance wellbeing. 3/

2 3 12 1,430

Discount rates are being significantly revised

Council of Economic Advisers @WhiteHouseCEA · 17h

The proposed revision substantially expands guidance on assessing distributional effects. It helps empower agencies to use income-weighted estimates in their analyses by providing them with a weighting methodology if they choose to do so. 6/

2 6 15 2,138

Council of Economic Advisers @WhiteHouseCEA · 17h

This option could be especially important in any context where regulations impact disadvantaged communities, which tend to have lower average income & lower property values. Income-weighted analysis can help ensure effects on these communities are not undervalued. 7/

2 2 11 1,246

Council of Economic Advisers @WhiteHouseCEA · 17h

The proposed revision removes the assumption that individuals affected by regulations are risk neutral. Risk aversion could be consequential for regulations that address areas such as climate change, student loan repayment, health insurance take-up, & pandemic preparedness. 8/

Discount rates are being significantly revised

Council of Economic Advisers @WhiteHouseCEA · 17h

Discount rates, which convert future values into present values, are key for analyzing long-term effects. Currently, Circular A-4 recommends two rates for all analyses: 3% and 7%. The proposed revision updates those rates to incorporate new economic data and methods. 9/

2 2 9 1,598

Council of Economic Advisers @WhiteHouseCEA · 17h

The proposed revision recommends a single primary discount rate & a separate accounting of capital investment effects and risk. Updating the data that produced the original 3% rate produces an updated rate of 1.7%, a critical change for regs with impacts far into the future. 10/

3 16 33 51.9K

Discount rates in the (very) long run

How should we think about discounting in the **very** long run?

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Giglo, Maggiori, and Stroebel (2015) come up with a clever way to think about discount rates in the far future: looking at UK and Singaporean housing markets

Discount rates in the (very) long run

In the UK and Singapore, properties are acquired via **leasehold** or **freehold**

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Discount rates in the (very) long run

In the UK and Singapore, properties are acquired via **leasehold** or **freehold**

- **Leasehold:** temporary, pre-paid, tradable ownership contracts with maturities of 99-999 years, once it expires, you lose the property
- **Freeholds:** same, but **perpetual** ownership, you never lose the property
    - Similar to how things work in the US

Property prices, what do they tell us?

Imagine there are two properties A and B, identical in every way except A is a leasehold with 500 years left until maturity and B is a freehold

Suppose we observe A selling for 900,000 dollars and B selling for 1,000,000 dollars

What do these prices mean? What value do they capture?

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Let's think about a simple example: you are a real estate investor deciding on purchasing a property to add to your rental portfolio in a competitive property market

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Suppose buyers were competing for a property that has a present value future rental stream of $900,000, what market price would we expect someone to pay for this?

$900,000! investors will compete, bidding higher and higher prices until it reaches the benefits of owning the property (same logic as why prices are the MB of regular goods in competitive markets)

Discount rates in the (very) long run

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Now let's go back to the original example:

Suppose we observe A selling for 900,000 dollars and B selling for 1,000,000 dollars

What does the price difference between the two properties tell us?

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Both properties are identical until year 500 when **poof**,

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The prices tell us about how the market discounts cash flows very, very far in the future, outside anyone's expected lifespan

Why do discount rates change over time?

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    - The future is getting richer slower, so the future's marginal value of a dollar is higher than if growth did not slow

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- **Changes in growth:** if growth slows down (e.g. from climate change), discount rates fall
  - The future is getting richer slower, so the future's marginal value of a dollar is higher than if growth did not slow
- **Uncertainty:** if we are uncertain about future economic conditions determining the discount rate (e.g. climate change), the discount rate we should use is lower than the average (expected) discount rate

Why do discount rates change over time?

Let's get a sense of how uncertainty over the proper discount rate matters

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What are the current expected costs of the project?

Why do discount rates change over time?

The current expected costs are just the costs averaged over either of the potential real discount rates:

$$\frac{1}{2}\frac{\$1\ \text{trillion}}{1.01^{100}} + \frac{1}{2}\frac{\$1\ \text{trillion}}{1.07^{100}} = \$185\ \text{billion}$$

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Now lets compute the value of the damages if we used the expected discount rate, the average of the two: 4%

$$\frac{\$1\text{trillion}}{1.04^{100}} = \$20\text{ billion}$$

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This means that the expected discount rate is too high compared to the actual discount rate we should be using if we are uncertain about future discount rates

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$$\frac{\$1 \text{ trillion}}{(1+r)^{100}} = \$185 \text{ billion} \qquad \rightarrow r = .017 = 1.7\%$$

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Main takeaway: Uncertainty about the future economic conditions governing the discount rate makes the discount rate we should be using lower than expected

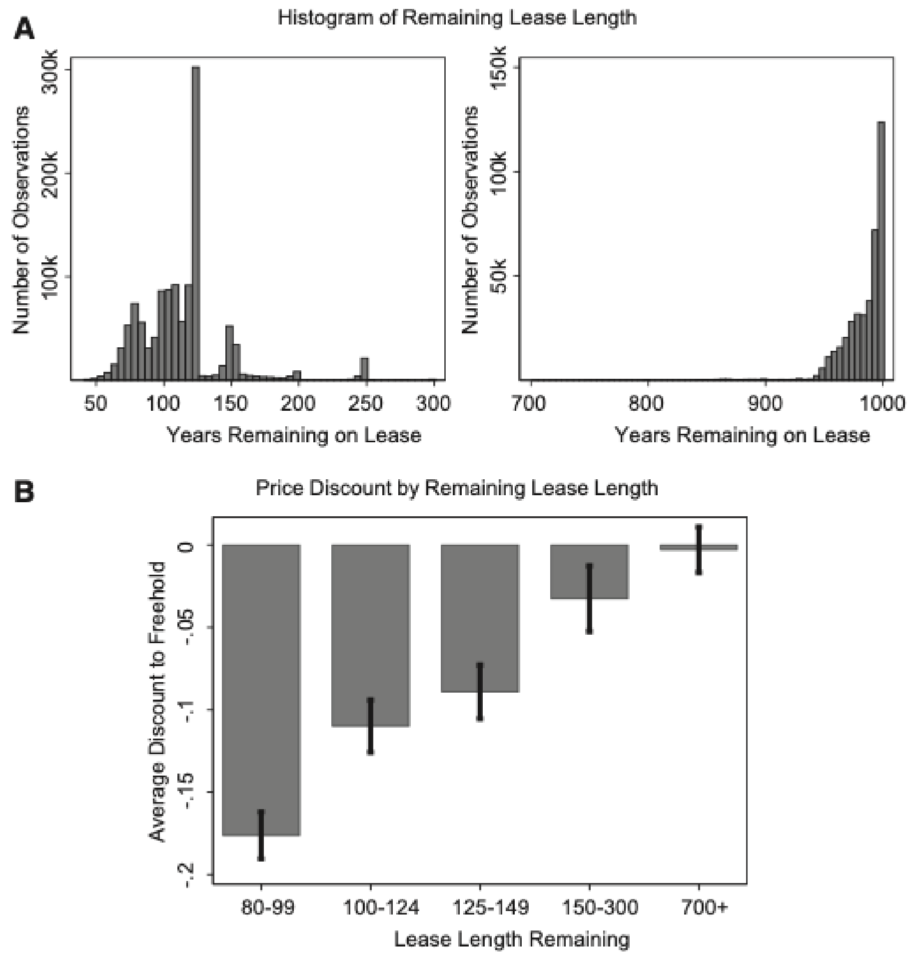
Discount rates in the (very) long run: United Kingdom

What are these long run discount rate?

In the UK:

- leases expiring within 100 years cost 17% less than a freehold
- leases expiring 150-300 years from now cost 5% less

Implies a discount rate of about **2.6%**



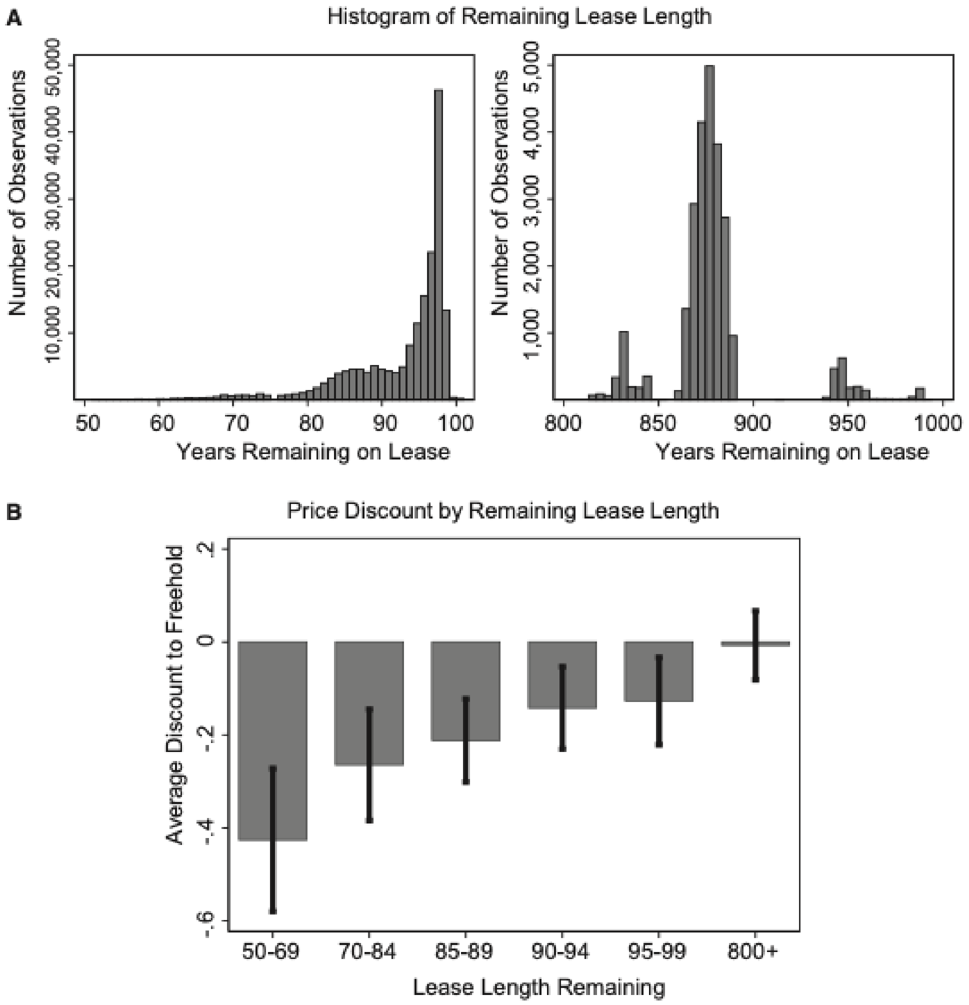
Discount rates in the (very) long run: Singapore

What are these long run discount rate?

In Singapore:

- leases expiring within 70 years cost 40% less than a freehold
- leases expiring 95-99 years from now cost 15% less

Implies a discount rate of about **2.6%**



Discount rates on rental payments

We can check the validity of these estimates by seeing whether **rental payments** depend on the length remaining of the contract

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There's no reason the rent you pay for your house should depend on how much longer the owner has property rights if your lease is short

Discount rates on rental payments

Rental rates (mostly) do not depend on the remaining lease time!