Problem Set: Discounting and the Social Cost of Carbon

Introduction

Many externalities occur in the future – ie an action taken today reduces the well-being of people at some later date. Since we might value utility today different from utility in the future, a Pigouvian tax should equal the **present value** of the external costs caused by an action. As discussed in class, the choice of discount rate can have a large impact on the appropirate Pigouvian tax.

The present value today of a cost that occurs T years from now is

$$PV = \frac{1000}{(1+r)^T}.$$

where r is the discount rate. If these were the only external costs caused by the action, this present value would also be the Pigouvian tax we would want to impose.

One way economists think about the appropriate social discount rate is the **Ramsey formula**:

$$r = \eta g + \rho,$$

where:

- ρ is the **pure rate of time preference**. We will consider either **0%**, meaning future utility is not valued less simply because it occurs later, or **2%**, meaning there is positive pure time preference (we value people living 35 years from now at about 50% of the value of people living today).
- g is the **real growth rate of consumption per person**. We will consider **0% growth**, **2% growth**, and **4% growth**, representing no, moderate, and high long-run growth.
- η describes how the marginal value of consumption changes as people become richer. We will consider:
  - $\eta = 0$: becoming richer does **not** reduce the marginal value of an additional dollar of consumption.
  - $\eta = 1$: a 1% increase in consumption reduces the marginal value of an additional dollar by approximately 1%.

These assumptions imply the following discount rates:

Pure time preference ρ	Consumption growth g	Marginal-value parameter η	Implied r
0%	0%	0	0%
0%	2%	0	0%
0%	4%	0	0%

Pure time preference ρ	Consumption growth g	Marginal-value parameter η	Implied r
2%	0%	0	2%
2%	2%	0	2%
2%	4%	0	2%
0%	0%	1	0%
0%	2%	1	2%
0%	4%	1	4%
2%	0%	1	2%
2%	2%	1	4%
2%	4%	1	6%

Q1. Discounting future external costs

Suppose an action taken today causes **$1,000 of external costs exactly T years from now**. [Assume that all dollar amounts and discount rates in this problem are in real (inflation-adjusted) terms.] This question asks you to construct a table showing how the present value of these external costs varies with the discount rate and the time until the damage occurs.

For discount rates, consider the distinct values in the Ramsey table above: $r = \{0\%, 2\%, 4\%, 6\%\}$. Plus add two additional cases that commonly used *private* discount rates:

- **7%:** approximately a long-run real return from investing in the stock market.
- **20%:** approximately the borrowing rate faced by someone carrying high-interest credit-card debt.

For each r consider the PV of costs incurred at the following times in the future: $T = \{10, 50, 100, 200\}$ years.

Construct a table with **discount rates as rows** and **years until the damage occurs as columns**, and the present value of the $1,000 external cost as the entries in the table.

Programming guidance:
There are many ways to complete this exercise, and you can use whatever programming language you are comfortable with or want to learn (ie R, Stata, Python, Matlab, etc.). [You can also use Excel if you must, but this really is a great way to get started vibe-codeing simple econ problems if you're new to programming.] Feel free to use AI to help you, but you must actually run the code on your own computer (vs just having AI generate the code and results for you). It is fine to directly copy over AI code or use an LLM locally on your computer.

High level steps:

- write a function or calculation that returns the present value of $1000 for any given discount rate r and time horizon T
- create the set of discount rates and time horizons you want to evaluate
- apply your present-value calculation to every combination of r and T
- organize the results into a table with discount rates in the rows and time horizons in the columns.

What to submit:

Present your results in a table with discount rates as rows and years until the damage occurs as columns. **Submit this table (or a screenshot of it) on Canvas.**

Q2. Choosing a social discount rate

If you were advising policymakers, what discount rate would you use when setting a Pigouvian tax on carbon emissions and why?

Just give me a number and short (1-2 sentence) justification. But come prepared to explain your reasoning in class.

Q3. Will a Pigouvian carbon tax on gasoline matter?

Burning gasoline emits carbon that will state in the atmosphere for hundreds of years. For this exercise, assume that burning one gallon of gasoline causes **7 cents of economic harm in every year for the next 200 years**.

Using the discount rate you chose in Question 2, calculate the present value of these future damages (ie the sum across 200 years):

$$PV = \sum_{t=1}^{200} \frac{0.07}{(1+r)^t}.$$

This is the Pigouvian tax on a gallon of gasoline implied by your chosen discount rate. **How large is this tax in dollars per gallon?**

Based on the size of the tax you calculate, **do you think a Pigouvian tax on gasoline would meaningfully reduce future climate change? Why or why not?**

[You do not need to submit your calculations for this question, but you should be prepared to explain your reasoning in class.]