903772087

GT ID number (do not write your name)

Midterm
ECON4210: Economics of Climate Change
Fall 2024
Prof. Wichman

Instructions

- This exam contains three parts:
  - Multiple choice (20 pts)
    - Choose only one answer.
  - True/false/uncertain, with justification (10 pts)
    - You need to provide a short (~1–2 sentence), but complete, answer justifying whether the statement is true or false.
    - It's possible that some statements require additional information to be true or false.
    - It's also possible that some statements could be both true and false, depending on the justification you provide.
  - Short answer (20 pts)
- You can use a one-page "cheat sheet" for the exam. You may not use any other references, books, or technology (e.g., phones or laptops). You may not look at your neighbors' exam.
- You may use a calculator.
- Your answers must be your own work. Cheating will not be tolerated.
- If you are confused about a question, or a question is unclear, you may ask for clarification (just come up to the front!).
- You should be familiar with the Georgia Tech Honor Code (available here: `https://policylibrary.gatech.edu/student-affairs/academic-honor-code`):

  Having read the Georgia Institute of Technology Academic Honor code, I understand and accept my responsibility as a member of the Georgia Tech community to uphold the Honor Code at all times. In addition, I understand my options for reporting honor violations as detailed in the code.

  Do you understand and accept your responsibility to uphold the Georgia Tech honor code?

  ☑ Yes
  ☐ No

- Good luck!

+2 = 89

87/100

1 Multiple choice (20 pts – 1 pt each)

1.1. Which of the following statements best describes the difference between climate and weather?

(a) Weather is the realization of a climatic process for a large geographic region over a long period of time.

(b) Weather represents long-run averages in climatic processes, like temperature, precipitation, and humidity.

(c) Climate is the long-run statistical average and variability of temperature, wind speed, humidity, and so forth, whereas weather is the realization of a climatic process over a short period of time.

(d) Climate is the moving average of weather that a particular region experiences over a period of at least 10 years.

1.2. The Coase Theorem says that when certain assumptions are met, parties acting in their own self interest can bargain to achieve the socially optimal solution. Which of the following is not an assumption that needs to be satisfied:

(a) There aren't too many parties involved.

(b) Property rights are clearly defined. ✓

(c) Property rights are given to the polluter.

(d) There are no (or low) transactions costs. ✓

1.3. The "free-rider problem" occurs when:

(a) Consumers benefit from a good without paying for it. ✓

(b) The government provides subsidies for public transportation.

(c) A market reaches equilibrium at no cost to society.

(d) Consumers overuse common resources like public parks.

1.4. Because greenhouse gas emissions are a global externality, US climate policy should:

(a) Wait until other countries reduce GHG emissions before adopting stringent climate policy. ✗

(b) Only focus on climate damages that accrue to US citizens. ✗

(c) Choose a higher discount rate because richer countries should "do their part" to help out poorer countries. ✓

(d) Target policies that internalize the full marginal external damages of emitting greenhouse gases. ✓

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1.5. Which of the following statements about discount rates is FALSE?

(a) Higher discount rates lead to much lower values of damages that occur far in the future. ✓

(b) Higher discount rates can be justified by the opportunity cost of capital. ✓

(c) A 5% discount rate is ethically justifiable because future generations will likely be wealthier than us. ✗

(d) Uncertainty in the discount rate can lead to higher discount rates, which is relevant for long-run uncertainties such as climate change. ✓

1.6. If you were using the Ramsey equation ($r = \delta + \eta g$) to choose a social discount rate and wanted to value the welfare of future generations equally to the present generation, you would:

(a) Set $\delta = 1\%$

(b) Set $\delta = 0\%$

(c) Set $\eta = 1$

(d) Set $\eta = 0$

1.7. If you were using the Ramsey equation ($r = \delta + \eta g$) to choose a social discount rate and wanted to reflect a strong aversion to unequal consumption across relatively poor generations and relatively wealthy generations, you would:

(a) Set $\delta = 1\%$
(b) Set $\delta = 4\%$
(c) Set $\eta = 1$
(d) Set $\eta = 4$

1.8. Which of the following statements about climate damages is TRUE?

(a) Climate damages are projected to be homogenous across the globe.
(b) The poorest countries are expected to see the least severe climate change impacts.
(c) Non-market goods and services, such as ecosystems and human health, are easily quantifiable and routinely included in economic models of climate change.
(d) Climate change may result in some countries being better off economically, potentially making international cooperation on climate policy more difficult.

1.9. Which of the following is NOT a criticism of using Gross Domestic Product (GDP) as a measure of economic well-being, particularly in the context of climate change?

(a) GDP does not account for the distribution of income within a country.
(b) GDP does not account for the depletion of natural capital that may occur as a result of economic activity.
(c) GDP is a readily available and widely used economic indicator that allows for comparisons of economic activity across countries and over time.
(d) GDP does not capture the value of non-market goods and services, many of which are negatively impacted by climate change (e.g., human health, ecosystem services, cultural heritage).

1.10. Suppose that the EPA changes the effective real discount rate from 3% to 7%. What would happen to the social cost of carbon (SCC) which is used in federal decision-making?

(a) The SCC would decrease because the far-distant future damages from climate change would be smaller in present value.
(b) The SCC would increase because the far-distant future damages from climate change would be larger in present value.
(c) The SCC would not change.
(d) The SCC would decrease substantially because climate damages that occur outside of the US no longer matter in the calculation of the SCC.

-1 1.11. Which of the following is most likely to be true regarding nonmarket climate impacts?

(a) Nonmarket climate impacts are generally well-understood and well-represented in the US government's construction of the social cost of carbon.
(b) Nonmarket climate impacts are easy to measure but it's difficult to place a dollar value on them because they're not traded in markets.
(c) Nonmarket climate damages are difficult to measure because they're not traded in markets.
(d) Nonmarket climate damages are not typically represented in the social cost of carbon because they are believed to be relatively small.

1.12. The beef industry generates greenhouse-gas emissions in the form of methane through raising livestock. Which of the following best describes the deadweight loss from consumption and production of beef?

(a) Deadweight loss is the welfare loss borne by both producers and consumers of beef if we were to consume at the socially optimal level.

(b) Because market forces already incorporate the external costs of beef, the deadweight loss is zero.

(c) Deadweight loss is the welfare cost that accrues to people outside of the beef market due to socially inefficient production of beef.

(d) Deadweight loss is the additional cost that producers pay when regulations make them account for the external damages from beef production.

1.13. Which of the following statements best describes the concept of "adaptation" in the context of climate change?

(a) Adaptation refers to actions taken to reduce greenhouse gas emissions.

(b) Adaptation refers to the process by which species evolve in response to environmental changes.

(c) Adaptation refers to the ways in which individuals, communities, and societies adjust to the actual or expected impacts of climate change.

(d) Adaptation refers to the economic costs associated with climate change impacts.

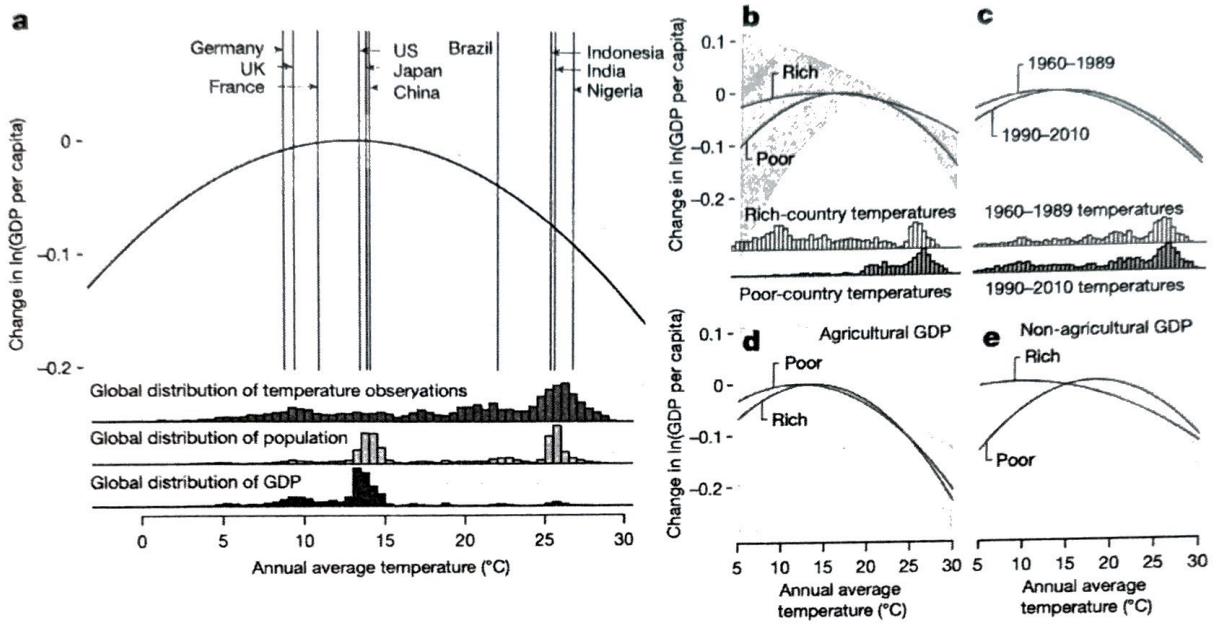


Figure 1: Main result from Burke, Hsiang, & Miguel, "Global non-linear effect of temperature on economic production," *Science*, 2015.

1.14. Consider the figure above from Burke et al. (2015) representing the weather-response function relating annual temperature to changes in GDP. Which of the following statements is not true?

(a) Germany is likely to benefit from an increase in temperature.

(b) Most of the wealthy countries in the world tend to have cooler temperatures on average.

(c) The "inverted U"-shaped weather-response function means that colder countries will suffer greater economic damages from increased temperatures than hotter countries.

(d) India is more likely to have more severe economic impacts from climate change than the US.

1.15. Consider the figure above from Burke et al. (2015) representing the weather-response function relating annual temperature to changes in GDP. Which of the following statements is best supported by panel (c)?

(a) The weather response-functions for both 1960–1989 and 1990–2010 are similar, which suggests that adaptation will help lessen the overall economic impact that countries' will experience in the future.

(b) The weather response-functions for both 1960–1989 and 1990–2010 are similar, which suggests that poorer countries cannot "catch up" in terms of economic growth.

(c) The weather response-functions for both 1960–1989 and 1990–2010 are similar, which suggests that there is little evidence of adaptation to hotter temperatures.

(d) 1960–1989 temperatures were generally cooler than 1990–2010, so we cannot infer how climate change might affect GDP.

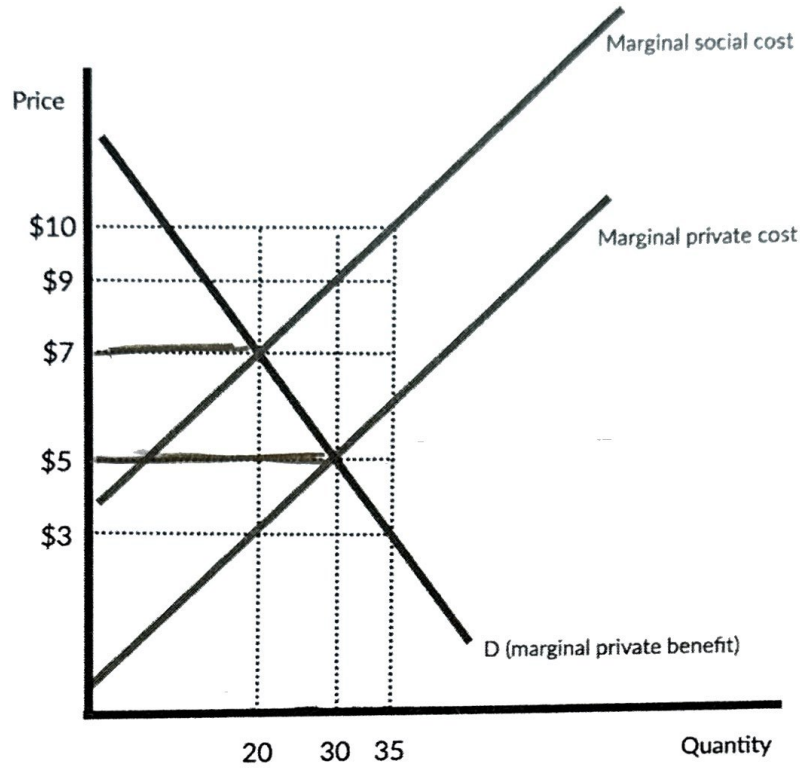


Figure 2: Marginal benefits and marginal costs with externalities.

1.16. Consider the figure above representing marginal benefits and marginal private/social costs. How much are the external damages for each additional unit produced?

(a) $4
(b) $5
(c) $7
(d) $9

$9 - 5 = 4$

1.17. Consider the figure above representing marginal benefits and marginal private/social costs. What is the value of deadweight loss if we operated at the privately optimal level.

(a) $18
(b) $20
(c) $24
(d) $40

$$\frac{(9-5)(30-20)}{2} = \frac{4 \cdot 10}{2} = 20$$

1.18. Consider the figure above representing marginal benefits and marginal private/social costs. If we moved from the privately optimal level of consumption to the socially optimal level of consumption, by how much would consumer surplus change?

(a) $10
(b) $20
(c) $30
(d) $50

$$(7-5)(20) + \frac{(7-5)(30-20)}{2}$$

$$= 40 + 10 = 50$$

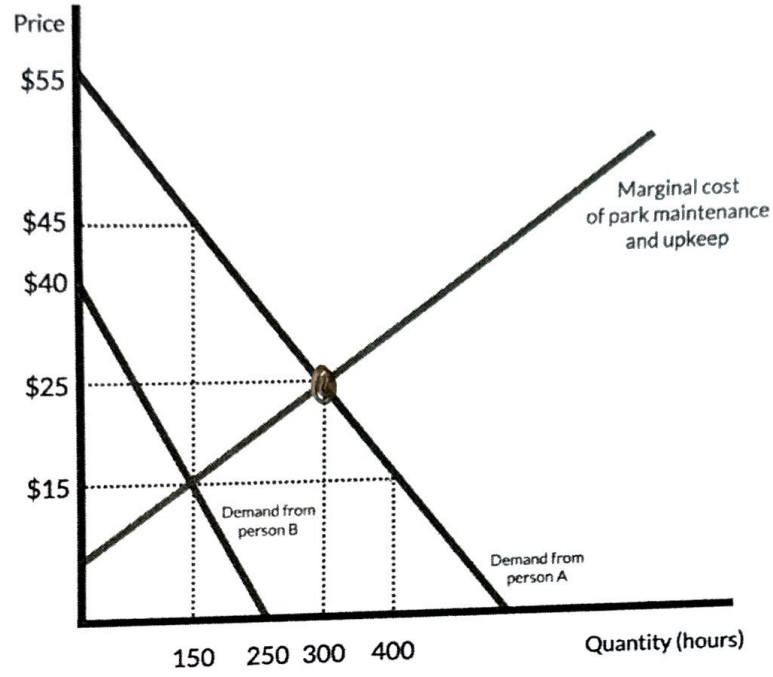


Figure 3: Demand for public park enjoyment and supply of maintenance from Person A and Person B.

1.19. Consider the figure above representing demand for public park enjoyment (a public good) as well as provision of upkeep and maintenance that is provided by those who use the park. How many total hours of maintenance would be provided in the private market equilibrium?

(a) 150 hours
(b) 250 hours
(c) 300 hours
(d) 450 hours

1.20. Consider the figure above representing demand for public park enjoyment (a public good) as well as provision of upkeep and maintenance provided that is provided by those who use the park. Which option below best represents what might occur in the private market equilibrium if both people acted in their self-interest?

(a) Person B and Person A would cooperate to provide 450 total hours of maintenance.
(b) Person B would freeride and Person A would provide 300 hours of maintenance.
(c) Person A would freeride and Person B would provide 150 hours of maintenance.
(d) Person B would freeride and Person A would provide 150 hours of maintenance.

2 True/False with justification (10 pts – 2.5 pts each)

2.1. The marginal benefits of greenhouse-gas mitigation are increasing because as we reduce GHGs, we prevent more and more climate damages from occurring.

False → diminishing marginal benefits/returns as we move closer to the goal, so less climate damages means less benefits quantitatively.

2.2. "Net zero" greenhouse-gas emissions is the point at which net surplus from climate change is maximized.

False → optimal amount of emissions is not net-zero GHG emissions even if economists want to maximize net benefits.
Consider supply theory of fossil fuels → lower GHG emission only through more extraction of fossil fuels.

-0.5 2.3. The primary damage sectors in recent integrated assessment models of the social cost of carbon (e.g., Rennert et al., 2022) only include market damages, such as the climate impacts on agricultural productivity and energy expenditures.

False → they include nonmarket damages as well

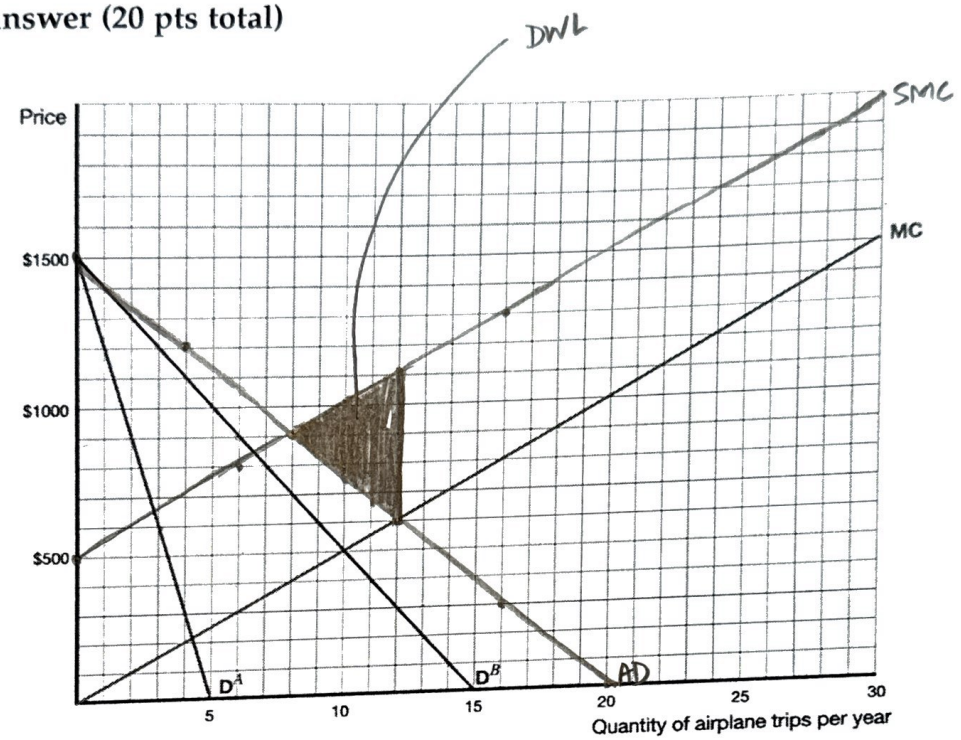
Not a complete response.

-1 2.4. Because gasoline consumption generates greenhouse-gas emissions, the private market equilbrium generates too much consumption and production of gasoline than is socially optimal.

True

Please, provide a justification for your response.

3 Short answer (20 pts total)



3.1. Consider the figure above, which represents the annual supply and demand of air travel for two individuals (A and B). Each individual's demand curve is represented by D^A and D^B. (Note: the graph is to scale).

(a) (1 pt) On the figure, draw and label the aggregate demand curve (e.g., "AD"). What is the equilibrium price and quantity in this market for air travel?

Price = \$600, Quantity = 12 airplane trips per year ✓

(b) (2 pts) Calculate the net surplus (total benefits minus total costs) at the private market equilibrium.

$(12)(\$1500)/2 = \boxed{\$9000}$ ✓

(c) (4 pt) Air travel generates greenhouse gas emissions through the burning of jet fuel. These emissions generate marginal external damages of \$500 per trip. Draw and label the social marginal cost curve ("SMC") that incorporates these external costs. What is the socially optimal number of trips per year? What price would generate the socially optimal number of trips?

trips = 8, price = \$900 ✓

(d) (2 pt) Shade and label the area of deadweight loss on the graph at the private equilibrium. What is the dollar value of deadweight loss?

$(12-8)(1100-600)/2 = 4 \cdot 500/2 = \boxed{\$1000}$ ✓

(e) (1 pt) Calculate the combined producer and consumer surplus loss if we moved from the private equilibrium to the social equilbrium.

$\$9000 - \frac{(8)(1500-500)}{2} = \$9000 - \$4000 = \boxed{\$5000}$ ✓

3.2. A subterranean reservoir of a new greenhouse gas (GHG-X) is discovered that is extremely potent, but has a very short lifespan (it disappears after 5 years in the atmosphere). Current exploration for minerals that are needed for electric car batteries is expected to disturb this reservoir and release all GHG-X into the atmosphere. All damages from GHG-X emissions will occur in the next 5 years. You are tasked with calculating the present value of damages that GHG-X generates. The warming effect of GHG-X is given as follows:

$$T = 0.5Y$$

where T is global mean surface temperature change and Y is the year.

A recent study was just published that showed that the climate damage function takes the following form:

$$D = 5 + 10T$$

where D is the economic damage (in billions of dollars) that arise from changes in global mean temperatures.

(a) (2 pts) In the table below, calculate the temperature change and economic damages from unmitigated GHG-X emissions from year 1 through year 5.

Year (Y)	Temp. (T)	Damages (D)	Discounted Damages
1	0.5	10	9.709
2	1.0	15	14.139
3	1.5	20	18.303
4	2.0	25	22.212
5	2.5	30	25.878

(b) (3 pts) Using a 3% discount rate, calculate the discounted stream of economic damages that GHG-X generates each year. Add these values to the table above.

$$\frac{D}{(1+0.03)^t}$$ (in table)

(c) (2 pt) What is the present value of the total stream of economic damages from GHG-X emissions?

$\sum_{t=1}^{5} \frac{D_t}{(1+0.03)^t}$ = $90.241 billion

(d) (1 pt) A university researcher has created a technology that can eliminate GHG-X emissions, but it will cost $100 billion today to scale. Should we invest the $100 billion today to stop GHG-X emissions?

In the sense of descriptive discounting, it would not make sense as that $100M could be invested and could have higher returns to offset the $90.241 billion in damages after the 5 years.

(e) (2 pt) One of your colleagues advocates for using a discount rate lower than 3% to discount GHG-X damages because they believe we have an ethical responsibility to value the welfare of future generations equally to our own. Does this argument make sense for GHG-X? Briefly explain why or why not.

Not necessarily because it has a short lifespan (only 5 years) and has to do with damages.