MIT 14.41 – Midterm

October 24, 2022

Instructions

- This is a closed-book exam
- You have 85 minutes to take the exam and there are 85 points on the exam; each point should correspond to approximately one minute
- Use a different blue book for responses to each section (Question 1, Question 2, Question 3)
- Please write neatly, we cannot give credit for illegible work
- You may use a calculator; if you do not have a calculator you may use your phone as a calculator

QUESTION 1: True, False, Uncertain (20 points)

For each question state whether the claim is **true, false, or uncertain** and explain why. You must give reasons or no points will be awarded.

1. (5 points) This is Maisie. She lives in Cambridge with Hannah, and, like many dogs, she **loves** to go to the dog park. But, there aren't many dog parks in Cambridge. Hannah should reassure Maisie that even though there aren't many dog parks for them to visit, they are surely being provided at the efficient level, because (a) a free market always provides goods at the socially efficient level and (b) if for some reason it didn't, the government would provide the optimal level because Cambridge's local government is democratic. (You can assume that Hannah, like all other dog owners, internalizes Maisie's preferences perfectly).

   Please respond separately for whether reasons (a) and (b) are true, false, or uncertain, and give a rationale for each.

2. (5 points) In the US, the government largely funds education through publicly-provided free schools rather than through providing vouchers for students to attend public or private schools of their choice. Claim 1: Providing vouchers instead would increase the amount/quality of schooling that students on average receive. Claim 2: This means that the government should switch to a voucher system.

   Please respond separately for whether Claim 1 and Claim 2 are true, false, or uncertain, and give a rationale for each.

3. (5 points) Many local communities in the US have restrictive zoning rules that limit the construction of housing. These zoning rules mean that the government should be more willing to redistribute from communities that have high levels of public goods to communities with low levels of public goods.

4. (5 points) In a setting where insurers **cannot** offer separate contracts to different types, (a) higher-risk types are always made better off than in a setting where insurers **can** offer separate contracts and (b) lower-risk types are always made worse off than a setting where insurers **can** offer separate contracts .

   Please respond separately for whether statements (a) and (b) are true, false, or uncertain, and give a rationale for each.

QUESTION 2: Pollution reduction (30 points)

A city receives its electricity from two power plants, plant A and plant B. These power plants both produce air pollution, which is harmful to the people in the city, meaning that there is a social benefit from reducing air pollution. A unit of air pollution does the same damage no matter which power plant it comes from. The people who run the power plants live outside the city, and do not suffer from the air pollution, so they get no private benefits from reducing air pollution. Both plants can invest in technology to reduce the pollution they emit at some private cost; the costs at each plant might be different. There are no additional social costs for reducing emissions – the only social costs are the costs to the plants.

1. (3 points) Explain what the externality is in this context, and why.

The government makes the following estimates:
The social benefits of carbon emissions reduction are constant at \$50 per unit of carbon reduction: $SB(r) = 50r$.
The government estimates that one of the plants has a private cost of carbon emissions reduction of $C_1(r_1) = r_1^2$, and the other plant has a private cost of $C_2(r_2) = 10r_2 + r_2^2$. However, it does not know which plant has which cost function. The plants cannot choose a negative reduction quantity, so are constrained to set $r_1 \geq 0, r_2 \geq 0$.

2. (6 points) Draw a diagram illustrating the social marginal benefit curve, and the marginal cost curves for the two firms. Calculate the socially optimal quantity reduction for each of the firms, and label these quantities on the diagram.

3. (5 points) Calculate the quantities of reduction chosen by each plant and the deadweight loss in the equilibrium where the government does not intervene.

4. (6 points) Describe (a) a tax or subsidy policy that achieves the social optimum, and (b) a command-and-control quantity regulation that achieves the social optimum. What information does the government need to know for each policy?

5. (6 points) Suppose the government thinks that plant A has the cost function $C_A(r_A) = r_A^2$, and plant B has the cost function $C_B(r_B) = 10r_B + r_B^2$. However, in fact it is the other way round: plant A's cost function is actually $C_A(r_A) = 10r_A + r_A^2$, and plant B's cost function is actually $C_B(r_B) = r_B^2$. If the government uses command-and-control quantity regulations, what quantities will it make plant A and B reduce emissions by based on its mistaken beliefs? Label these $\hat{r}_A, \hat{r}_B$ respectively. Calculate the deadweight loss from this mistake.

6. Suppose now that the government is worried about getting this wrong, so it switches to a tradable permits scheme. Under this scheme the government gives permits that mean plant A has to reduce emissions by $\hat{r}_A$ and plant B has to reduce emissions by $\hat{r}_B$ (as calculated in the previous question), but it allows the plants to buy or sell some of their permits to each other.
   (a) (2 points) What is the quantity that each plant would trade?
   (b) (2 points) What price would the permits trade for?
   (c) (1 point) What is the deadweight loss from the new equilibrium outcome?

QUESTION 3: Funding Fire Departments (35 points)

Before 2013, the state of Victoria in Australia financed fire stations and services by a tax, $\tau > 0$, on home fire insurance policies. To understand the effects of a policy like this one, let's assume the following:

Households can purchase an amount of fire insurance coverage f at actuarially fair price of p in the absence of the tax, and an amount of all other consumption c at a price of 1. All households have an income y to spend on f and c. Assume that there are two households, and they choose f_1 and f_2, respectively.

Regardless of their purchase of fire insurance, households receive the services of the fire department. Denote the quantity of the fire department's services F which is equal to the total tax revenue collected to fund the fire department: $F = \tau(f_1 + f_2)$

A household's value of insurance is parameterized by α. α summarizes characteristics of the household, like risk of fire and risk aversion. Specifically, someone with a higher α may be more risk averse or be at a higher risk of their house catching fire. Therefore, they place more value on both how much funding the fire department has and on having insurance. *Until part 6* assume that every household has the same α. Specifically, we can write the expected utility of a household i as:

$$u_i = ln(c_i) + \alpha ln(F + f_i)$$

and their budget constraint as:

$$y = (1 + \tau)pf_i + c_i$$

1. (5 points) Find the optimal level of f_1 that the first household chooses when they are individually maximizing expected utility, taking as given the decisions of the other household as f_2. Directionally, how does f_1 depend on f_2 and why?
2. (3 points) What will be the private equilibrium value of F, $F^\star$?
3. (5 points) Define social welfare as the sum of both households' expected utilities. If the social planner was choosing everyone's insurance policies to maximize social welfare, how much fire insurance would they mandate each household to buy? What is the optimal level of funding for the fire department, F^s?
4. (2 points) Compare $F^\star$ and F^s. Is the privately chosen level of funding for the fire-department higher, lower, or the same as the the socially optimal level?
5. In this part of the problem only, suppose that the government decided to provide a lump-sum T to the fire department, in addition to the tax revenue generated by households' purchases of fire insurance. The lump-sum T comes out of other government revenue: it is *not* generated through any additional tax on households.
   (a) (4 points) What new level of f does each household choose when they are individually maximizing expected utility?
   (b) (4 points) Imagine the government sets T equal to the difference between the socially optimal level of fire department funding and the level obtained when individuals are maximizing utility that you found in part 2 (i.e. $T = |F^s - F^\star|$). Given the results you found above, will the government achieve the social optimum using this policy? Why? (No additional math required).
6. Finally, assume that the insurance company has gone out of business (i.e. no one can purchase any private insurance) and the government has decided that they should finance the fire department through a lump-sum tax

t on each household (and the government will no longer make the lump-sum payment T out of other government revenue). They will put to a vote what the level of that tax should be. Now, let's assume that there are 80 households of type 1 ($\alpha = \alpha_1$) and 20 households of type 2 ($\alpha = \alpha_2$), with $\alpha_2 > \alpha_1$. So, $F = 100t$.

(a) (2 points) What is a household of type i's utility function?

(b) (4 points) Using the same social welfare function as above, what is the socially efficient level of the lump-sum tax t?

(c) (3 points) What level of the lump-sum tax does each voter vote for? Who votes for a higher tax?

(d) (3 points) Will the vote lead to an efficient level of the tax? Why or why not?

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