# Midterm

14.41 Public Finance and Public Policy

85 Minutes Allowed

## Instructions

- Use a different blue book for responses to each section (Question 1, Question 2, Question 3)
- Please write neatly; illegible work will be given no points.
- No calculators are allowed.

## Question One [16 points]

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

1. Climatologists are sure that the marginal social benefit of each tonne of carbon dioxide abated is \$50, while the private marginal benefit is 0. Economists are unsure about the marginal cost functions of the firms that would actually do the abating.

   Claim: In this situation a quantity restriction is the best way for the government to reduce deadweight loss.

2. A park is being planned for Somerville. The cost will be \$1,000. It will be financed by asking what each of the 100 local residents are willing to pay for this park, and charging them each the number they report. Assume these are the only benefits or costs that matter. Everyone reports \$ 11, and so the estimated net benefit is \$1100.

   Claim: given these reports, the park should be built.

3. Claim: In order to redistribute from the advantaged to the disadvantaged, education should be provided by local governments.

4. The government is considering investing in a public works project that would produce \$10 in social benefits. The project can be completed using one unit of a special material made by a monopolist. It costs the monopolist \$5 but is sold to the government for \$15.

Claim: The government should not undertake the project.

## Research and Development [30 points]

Alice and Bob have pursued their lifelong goals of becoming successful inventors, and today they each manage a large firm. Firms A (Alice) and B (Bob) sell widgets to consumers in competitive markets, and initially assume that each firm caters to different consumers: Consumers in the market for widget A would never buy widget B, and consumers in the market for widget B would never buy widget A.

Consumers are willing to pay more for higher quality widgets, and Alice and Bob can improve their widgets (and earn higher profits) by employing scientists who do research and development (R&D). Scientists can be employed at the perfectly competitive wage $w$, and let $l_A$ and $l_B$ denote the number of scientists employed by Alice and Bob, respectively. The scientists at each company often publish papers about their research and talk to other scientists at conferences, exchanging ideas and knowledge. As a result, if Alice and Bob employ $l_A$ and $l_B$ scientists, the total profits earned by firms A and B from the sale of their widgets are

$$\pi_A(l_A, l_B) = 4(l_A l_B)^{1/4} - w l_A \quad \text{and} \quad \pi_B(l_A, l_B) = 4(l_A l_B)^{1/4} - w l_B.$$

Suppose that Alice and Bob separately choose the number of scientists to employ to maximize their profits, taking the number employed at the other company as given.

1. (4 pts) Assuming a positive number of scientists are employed, how many scientists do Alice and Bob employ in equilibrium?

2. (7 pts) What employment levels are socially optimal? Explain why these are not achieved in equilibrium.

3. (4 pts) Describe a possible Coasean solution to this externality. How does the feasibility of this solution depend on the number of firms undertaking R&D?

4. (4 pts) Suppose that the Coasean solution is not implemented by Alice and Bob. The government decides to correct the market failure by subsidizing the wages of scientists, so Alice and Bob must now pay wage $(1-s)w$. The subsidy is paid for by a lump-sum tax on the earnings of Alice and Bob. What is the optimal wage subsidy rate $s$?

5. (4 pts) Now suppose that Alice and Bob are in competition with each other: If Alice improves her widget through R&D, she steals some business from Bob, and this accounts for some of the profits that she earns from innovating. In this case, the profits earned through widget sales are

$$\pi_A(l_A, l_B) = 4(l_A l_B)^{1/4} - w l_A - \sigma l_B \quad \text{and} \quad \pi_B(l_A, l_B) = 4(l_A l_B)^{1/4} - w l_B - \sigma l_A.$$

   Here $\sigma > 0$ parametrizes the strength of "business stealing." Again assuming a positive number of scientists are employed, how many scientists do Alice and Bob employ in equilibrium?

6. (7 pts) What employment levels are socially optimal? Are equilibrium employment levels too high or too low, and how does this depend on $\sigma$? Describe the intuition.

## Question Three [39 points]

In Massachusetts funding for public universities is being debated. There are two types of people, college students and non-students. College students derive a large benefit from money spent on education. For simplicity assume the entire population of Massachusetts consists of 1 student and 2 non-students. The student is numbered 1, and the non-students 2 and 3. Denote the total spent on education by $E = e_1 + e_2 + e_3$. The utility of the student 1 is

$$U_1 = \ln(x) + \ln(E).$$

Non-students enjoy smaller benefits from higher education spending. Their preferences are

$$U_2 = U_3 = \ln(x) + \frac{1}{2}\ln(E).$$

Both types of people have income $Y$ and spend their money on other goods $x$ or contribute to higher education $e$. Assume the prices of both are 1.

1. (5pts) What contribution to public education, $e_1$, will student 1 choose in terms of $e_2, e_3$ and $Y$?

2. (4 pts) What contribution to public education, $e_2$, will non-student 2 choose in terms of $e_1, e_3$ and $Y$?

3. (4 pts) Explain the effect of an increase of $e_1$ on $e_2$. Explain the effect of an increase of $e_3$ on $e_2$. Which has a larger impact on $e_2$ and why?

4. (4 pts) Assuming both non-students contribute the same amount, $e_2 = e_3 = e'_e$, show that in equilibrium $e_1^* = \frac{Y}{2}$ and $e' = 0$. Explain intuitively why $e' = 0$.

5. The following scheme applies only to this question.

   (4 pts) In question 4 we found that the total expenditure under the private equilibrium to be $E^* = \frac{Y}{2}$. In order to improve fairness, someone suggests we instead fund the same total education equally: everyone pays $\frac{Y}{6}$. Someone else suggests that while $\frac{Y}{6}$ should be the minimum, people should be able to contribute more if they wish to. **Without solving any new optimization problem,** will anyone want to pay more than the $\frac{Y}{6}$ minimum? Explain why or why not in relation to the incentives at the private equilibrium.

6. (4 pts) Suppose the government is considering giving a dollar to either student 1 or non-student 2 that had to be spent on education (e.g. a voucher). Which would raise total education spending by more, giving it to student 1 or to non-student 2? Please explain.

7. (5 pts) If welfare is $W = U_1 + U_2 + U_3$, find the socially optimal level of $e_1$ and $e'$. Also find the difference in total education expenditure under the private equilibrium relative to the social optimum.

8. (5 pts) Suppose the government gives student one a block grant of size $g > 0$. What is the size of the block grant $g$ needed to get total education spending to the social optimum? Is it bigger or smaller than the difference between education spending at the old private equilibrium (from part 4) and the social optimum (from part 7)? Why?

   (Hint: before doing calculus think first about how much the non-students will spend on education)

9. (4 pts) Recall in the private equilibrium level of public education spending was $E^* = \frac{Y}{2}$. Separately, MIT generously decides to offer the student admission for free. Going to MIT delivers utility of $U_1 = \ln(Y) + \ln\left(E^{MIT}\right)$ since the cost is zero all money can be spent on the other good. Assume $E^{MIT} < \frac{Y}{2}$. Assume that if the students attends MIT they do not have to contribute toward the public university.

   Draw the students old (part 1) and new (this part) budget sets, noting their optimal point if they choose MIT and their optimal point if they go to the public university. Explain why financial aid programs at private universities might reduce the total expenditure on education.

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