Economics 134 Final Exam, Fall 2024

December 8, 2024, 3pm–6pm

Write your name and UID in the upper right corner of each page to help the robots conduct OCR.

You have three hours to complete this exam. Show your work.

QUESTION 1 (40 points). True or false.

(a) Someone who lives in a wildfire risk zone—and would live there regardless of whether they have to pay the full cost of fire suppression efforts—is an example of inefficiency due to moral hazard.

> **Solution:** False. There is no inefficiency or moral hazard because not bearing the cost of fire suppression does not affect this person's location decision.

(b) As discussed in lecture, Germany built a lot of solar power at the same time as decommissioning a lot of nuclear power. If Germany had not installed any solar and instead had kept using all of its nuclear power during this period, its total carbon emissions might have been lower.

> **Solution:** True.

(c) Recent work by economists has estimated that, had the Organization of Petroleum Exporting Countries (OPEC) not colluded to restrict oil production from 1970–2021, the world's historical carbon emissions would have been much lower due to the absence of OPEC's market power.

> **Solution:** False. Emissions would have been higher.

(d) By allowing lower-cost forest management projects to substitute for more costly traditional abatement at fossil fuel facilities, California's forest offset program can lower the costs of meeting the state's climate goals, provided that these offsets deliver true carbon reductions.

Solution: True.

(e) Subsidies for electric vehicles in the US coincided with innovation in battery technology that lowered costs, providing one potential justification for these subsidies.

Solution: False; correlation is not causation. If this innovation were caused in part by the subsidies, then that would be a justification if the innovation involved positive externalities (i.e., was not just economies of scale).

(f) If chemical manufacturers produce unregulated toxic waste that harms the environment, and the two largest such firms merge to exert market power and lower output, then the merger will help the environment—even though consumers of the chemical products will be worse off.

Solution: True.

(g) If the damages from climate change are more uncertain, we should lower our discount rate to account for this greater uncertainty in our long-run cost-benefit analysis.

Solution: False.

(h) When the assumptions of the Coase theorem hold, the outcome is efficient without needing to impose a corrective policy like the Pigouvian tax or an optimal regulation.

Solution: True.

(i) In the models we study in class, there is necessarily a tradeoff between efficiency and equity.

Solution: False. Many different distributional outcomes may all be equally efficient.

(j) In both the common-pool and public goods problems studied in class, inefficiency increases in the number of firms or people that use the common-pool resource or benefit from the public good.

Solution: True.

QUESTION 2 (50 points). Christmas toys.

(a) Santa's elves obtain profit $\pi(q) = 10q - \frac{1}{2}q^2$ if they produce q toys. Calculate the profit-maximizing quantity of toys the elves will produce and the profits they will obtain.

Solution: The profit-maximizing quantity solves $\pi'(q^*) = 0$ or $10 - q^* = 0$ or $q^* = 10$ toys, for profit of $\pi(q^*) = \pi(10) = 100 - \frac{1}{2} \cdot 10^2 = 50$.

(b) Suppose the toys are then shipped to children, creating $D(q) = q + 4q^2$ of environmental damage. Calculate the total damage created by profit-maximizing toy production in (a).

Solution: $D(q^*) = D(10) = 10 + 4 \cdot 10^2 = 410$.

(c) Calculate the efficient or "first-best" level of toy production and total welfare (elf profits minus environmental damage) under the first-best.

Solution: Maximizing $\pi(q) - D(q)$ or $10q - \frac{1}{2}q^2 - q - 4q^2$, we get $\pi'(q^{\mathrm{FB}}) - D'(q^{\mathrm{FB}}) = 10 - q^{\mathrm{FB}} - 1 - 8q^{\mathrm{FB}} = 0$, or $9 - 9q^{\mathrm{FB}} = 0$, or $q^{\mathrm{FB}} = 1$ toy.

(d) What Pigouvian tax on the elves will lead them to produce the efficient number of toys?

Solution: A tax of $D'(q^{\mathrm{FB}}) = 1 + 8q^{\mathrm{FB}} = 9$ at $q^{\mathrm{FB}} = 1$ per toy.

(e) Calculate the net benefits to society of imposing the Pigouvian tax on Santa's elves.

Solution: Net benefits are defined as

$$\left[\pi(q^{\mathrm{FB}}) - D(q^{\mathrm{FB}})\right] - \left[\pi(q^*) - D(q^*)\right].$$

We already know that $\pi(q^*) = 50$ from (a) and $D(q^*) = 410$ from (b). So

$$\pi(q^*) - D(q^*) = -360.$$

And $\pi(q^{\text{FB}}) = 10 \cdot 1 - \frac{1}{2} \cdot 1^2 = 9.5$, and $D(q^{\text{FB}}) = 1 + 4 \cdot 1^2 = 5$. So

$$\pi(q^{\text{FB}}) - D(q^{\text{FB}}) = 9.5 - 5 = 4.5.$$

Drawing everything together, the benefits are $4.5 - (-360)$, or 364.5.

(f) Suppose that Santa's elves form a union and decide to restrict toy production to no greater than $\overline{q} = 4$ toys, so that they can have a longer holiday. Does this improve welfare relative to the profit-maximizing allocation in (a)? Relative to the Pigouvian tax in (e)?

Solution: Welfare should improve relative to (a) but diminish relative to (e). This can be seen either from noting that welfare is always strictly increasing as we lower q from q^* to q^{FB}, or by calculation: $\pi(4) - D(4) = 10 \cdot 4 - \frac{1}{2}4^2 - 4 - 4 \cdot 4^2 = 40 - 4 - 4 - 64 = -32$, and $-32 > -360$ but $-32 < 4.5$.

(g) Santa's elves have now abandoned their union idea, but have learned that they are the monopolist supplier of Christmas toys to Santa. Specifically, Santa will pay a per-toy price $P(q) = 10q^{-1/2}$, making the elves' new profit function $P(q)q - \frac{1}{2}q^2$. Without doing any math, explain whether the optimal tax will be higher, lower, or the same as in (d). *Hint: q^{FB} here is still the same as in (c).*

Solution: The optimal tax falls because we do not want the elves to further exercise their market power!

QUESTION 3 (50 points). Public goods on the Pacific Coast Highway.

Suppose that drivers in Malibu can drive more carefully by exerting $g_i \geq 0$ units of effort, which they dislike. The total level of effort to be careful by N drivers in Malibu equals $G = \sum_{i=1}^{N} g_i$.

Utility for drivers in Malibu is $u(g_i, \theta_i) = -\frac{1}{2}g_i^2 + \theta_i G$.

There are two types of drivers, $i \in \{A, B\}$. Types $\theta_A = 0$ never bike in Malibu and do not value total carefulness, whereas types $\theta_B = 1$ sometimes bike in Malibu and do value total carefulness.

(a) What is the privately optimal effort level for a type A driver? For a type B driver?

Solution: Type A driver maximizes $-\frac{1}{2}g_i^2$, thereby setting $g_A^* = 0$.

Type B driver maximizes $-\frac{1}{2}g_i^2 + \theta_B G$, thereby setting $g_B^* = 1$.

(b) Suppose that there is 1 type A driver and 1 type B driver. How much effort should drivers A and B exert to maximize their total surplus? Explain why your answers differ from in (a), if at all.

Solution: Maximizing $-\sum_i g_i^2 + \sum_i \theta_i G$ over each i gives $g_A^* = g_B^* = 1$. Our answer for person A's effort differs from (a) because now we are requiring that person A (who doesn't care about B when they are undertaking their effort level) to internalize the benefit. Note that B's effort is the same, since they fully internalize the value of their public goods contribution, since they are the only person who enjoys it!

(c) Does moving from the privately optimal contributions in (a) to the optimal public good provision in (b) create a Pareto improvement? Explain.

Solution: No, since driver A is worse off.

(d) Now suppose that there are 10 drivers, all of type B. How much effort should each driver exert to maximize total surplus? Does this create a Pareto improvement relative to the world in which each driver instead maximizes their own private utility? Explain.

Solution: Optimal effort maximizes $g_B^* = \sum_{i=1}^N \theta_i = 10$, in contrast to $g_B^* = 1$ from (a).

Yes, it's a Pareto improvement, since all drivers are better off. The difference here from (c) is that drivers are symmetric and in particular value the sum of everyone else's greater contributions more than they dislike the additional effort that they undertake (in contrast to (c), where driver A did not value the public good, so they were worse off by undertaking additional effort).

(e) Earlier this year, the City of Malibu contracted the California Highway Patrol to provide \$2 million worth of additional resources to patrol the Pacific Coast Highway. What would need to be the case for this contract to deliver the first-best level of driver care?

Solution: The CHP needs to ticket all drivers who exert effort less than $\sum_i \theta_i$, which is the first-best level of contribution g_i^{FB} for each i. This delivers the first-best level of protection for cyclists, assuming that ticket fines exceed the disutility from exerting g_i^{FB}—then everyone will exert exactly g_i^{FB}.

QUESTION 4 (20 points). Climate change.

Suppose that we think all climate damages will occur in the year 2124 (100 years from today), and they will equal $10,000/ton of carbon in that year.

(a) Suppose that $\rho = 0.1\%$, $g = 2\%$, and $\theta = 2$. Calculate the discount rate using Ramsey's rule and the implied social cost of carbon today.

Solution: The discount rate is $r = \rho + \theta g = 0.1\% + 2 \cdot 2\% = 4.1\%$.

The social cost of carbon is

$$\text{SCC}_{2024} = \frac{1}{(1+0.041)^{2124-2024}} \cdot 10^4 = 1/1.041^{100} \cdot 10^4 = \$179.85/\text{ton}.$$

Note that this value is suspiciously close to the EPA (2022) value!

(b) Suppose that now the economy is expected to decline, so that $g = -1\%$. Recalculate the social cost of carbon, and compare your answer to (a). Which answer is closer to the range of social costs of carbon studied in class?

Solution: Now $r = \rho + \theta g = 0.1\% - 2 \cdot 1\% = -1.9\%$. Then

$$\text{SCC}_{2024} = \frac{1}{(1-0.019)^{100}} \cdot 10^4 = \$68{,}092.50/\text{ton}.$$

This is a much bigger number than in (a), and much farther from the range of social costs of carbon studied in class than (a).

QUESTION 5 (40 points). California salmon.

Evan likes to go fly fishing. He derives utility $u(q) = 8q - q^2$ from spending q hours fishing today.

(a) How many hours will Evan spend fishing today if he maximizes his utility?

Solution: $u'(q) = 0$ or $8 - 2q^* = 0$ or $q^* = 4$ hours.

(b) Evan has a probability $p = \frac{1}{2}$ of catching one fish each hour he spends fishing. Calculate the maximum number of hours society should allow Evan to go fishing if each fish's dislike of being caught is -4 units of utility and we maximize total expected surplus among Evan and the fish.

Solution: Welfare is now $u(q) - 4pq$, since we need to subtracted the expected loss to the fish. Since $p = \frac{1}{2}$, this gives us $6 - 2q^{\mathrm{FB}} = 0$ or $q^{\mathrm{FB}} = 3$ hours.

(c) Further suppose that

- Evan has to go to work and can only fish at most 1 hour,
- there is only one fish left, and if Evan catches it the species goes extinct, and
- future generations obtain $v = 1$ units of utility every day from tomorrow until forever if the fish species continues to exist.

If we discount future days by a factor of $\beta = 0.9$, and maximize the sum of discounted expected utility of Evan, the fish, and future generations, should we allow Evan to fish at all?

Solution: Evan's utility from fishing $q = 1$ hour is $8q - q^2 = 7$. The fish's expected disutility of being caught is $-p \cdot 4 = -\frac{1}{2} \cdot 4 = -2$. Society's value of fish conservation is $\sum_{t=1}^{\infty} \beta^t v = \frac{\beta}{1-\beta} v = \frac{.9}{1-.9} v = 9v = 9$ when $v = 1$. Since Evan has a chance $p = 1/2$ of catching the fish, this makes the expected loss to future generations equal to 4.5, less than Evan's utility net the fish of 5. So we should let Evan fish (!).

(d) How does your answer to (c) change if Evan buys a new fishing rod, which raises his chance of catching the last fish to $p = 2/3$?

Solution: Now we ban Evan from fishing, since the expected loss to future generations is now $9 \cdot \frac{2}{3} = 6$, which is greater than Evan's utility net of the fish's tastes.