Economics 134 Fall 2022 Midterm 1 — Solutions

October 24, 2022

You have 75 minutes to complete this exam. Show your work.

QUESTION 1 (70 points). Apples.

A firm owns an orchard that produces $q \geq 0$ apples for a cost $\frac{1}{2}q^2$. The firm can sell apples for a constant price p per apple.

(a) Suppose $p = 9$. If the firm maximizes profits, how many apples will the firm produce?

Solution: Profits are $\pi(q) = pq - \frac{1}{2}q^2$, which is maximized when $\pi'(q^*) = p - q^* = 0$, or $q^* = p = 9$.

(b) To grow apples, the firm uses pesticides, which endanger a nearby community of herons. Through a series of experiments, some UCLA students have estimated that total environmental damage equals $D(q) = 4q^2$.

If $p = 9$, and welfare equals the firm's profits minus the environmental damage, what is the efficient (or "first-best") level of apple production?

Solution: Maximizing $\pi(q) - D(q)$ with $\pi'(q^{\text{FB}}) - D'(q^{\text{FB}}) = 9 - q^{\text{FB}} - 8q^{\text{FB}} = 0$, or $q^{\text{FB}} = 9/9 = 1$.

(c) Calculate the difference in the firm's profits between (a) and (b). Is the firm better off under the efficient outcome?

Solution: Under (a), the firm chooses $q^* = 9$ and makes $pi(q^*) = 81 - \frac{1}{2} \cdot 9^2 = \frac{81}{2}$.

Under (b), the firm chooses $q^{\text{FB}} = 1$ and makes $\pi(q^{\text{FB}}) = 9 - \frac{1}{2} = \frac{17}{2}$.

The difference is $\pi(q^*) - \pi(q^{\text{FB}}) = \frac{81}{2} - \frac{17}{2} = \frac{64}{2} = 32$. The firm is clearly worse off.

(d) Calculate the difference in environmental damage between (a) and (b), and compare with your answer to (c). Use your calculations to recommend a policy discussed in class, if any, that will improve welfare. Will the policy satisfy the Kaldor-Hicks criterion?

Solution: The difference in environmental damage is $D(q^*) - D(q^{\text{FB}}) = 4 \cdot 9^2 - 4 \cdot 1^2 = 4 \cdot 81 - 4 = 4 \cdot 80 = 320$.

This number is significantly larger than $\frac{63}{2}$, implying large net benefits to regulation.

Some policies that work include the optimal tax or regulation.

The efficient policy will satisfy Kaldor-Hicks (i.e., it is a Pareto improvement with transfers) because it increases total surplus, so a transfer will make it a Pareto improvement.

(e) Is it possible to generate a true Pareto improvement on the free market outcome in (a)? Explain.

Solution: Yes; implement the efficient quantity (e.g., with a quantity rule or a tax), then transfer resources to the firm equal to or greater than the firm's foregone profits, but less than the total benefits for the herons.

(f) Calculate the optimal per-apple tax, τ, on the firm's output. Suppose that the firm pays the tax when it decides q. After the firm sells its apples, we give the firm a lump-sum transfer equal to $R = \tau q^{\text{FB}}$. Is this efficient? Is the firm better off under the free market?

Solution: The optimal tax is $\tau = D'(q^{\text{FB}}) = 2 \cdot 4q^{\text{FB}} = 8$.

Yes, this is efficient, for the reasons in (d) and because the transfer is lump-sum (does not depend on q, only q^{FB}, which is fixed and not dependent on the firm's actual choice of q) so it does not affect

Yes, the firm is better off under the free market. The firm's total profits at q are $\tilde{\pi}(q) = \pi(q) - q\tau + R$. Under the optimal tax, we know the firm chooses $q = q^{\text{FB}}$. The firm ends up with $\pi(q^{\text{FB}}) - q^{\text{FB}}\tau + R = \pi(q^{\text{FB}})$, which is less than $\pi(q^*)$, as we know from our answer to (b).

QUESTION 2 (20 points). Military health records.

The severity of air pollution varies across the United States due to various local economic and environmental factors.

(a) Suppose that you find, on average, people living in places with 10% less air pollution than the average are 8% less likely to be hospitalized for a lung condition. What does this imply about the effect of a policy to reduce air pollution by 10% in places with average pollution?

Solution: Nothing; correlation is not causation.

(b) You have obtained medical records from the U.S. military, which randomly assigns individuals to military bases. Different military bases are in different parts of the United States, so some bases are more exposed to air pollution than others.

You find that, on average, individuals randomly assigned to military bases with 10% less air pollution than the average are 2% less likely to be hospitalized for a lung condition.

Under what assumptions will reducing pollution by 10% at the average base lower the hospitalization risk for lung conditions by 2% for individuals assigned to that base?

Solution: Assignment to the base is random. We need that the differences in hospitalization risk for lung conditions only arise through differences in pollution across military bases.

(c) Suppose you find that, on average, military bases with 10% lower air pollution also have 25% fewer liquor licenses per capita. If liquor licenses increase alcohol consumption (and the likelihood of hospitalization for lung conditions), how might that affect your answer to (b)?

Solution: This is an example of an omitted variable which is correlated with the treatment (assignment to a low-pollution base) and the outcome (likelihood of hospitalization for lungs). Without controlling for this variable, our stated assumptions in (b) will no longer hold.

(d) How could you use data on the number of liquor licenses near military bases to improve your estimate of the economic costs of air pollution?

Solution: Control directly for the number of liquor licenses in the regression that predicts hospitalization risk with the military base's pollution.

QUESTION 3 (20 points). Interceptor 007.

The Interceptor 007 is a new device that can stop pollution into the Santa Monica Bay.

An exhaustive study has determined that the Interceptor will improve the quality of the beaches in Santa Monica. The estimates indicate this quality improvement will generate $2 million of new tourism tax revenue for the City of Santa Monica.

Assume that UCLA owns the Interceptor and can either use it to stop pollution or send it back to Malaysia for a one-time payment of $100,000. Also assume that UCLA maximizes its profits and derives no utility from lowering pollution in the Santa Monica Bay.

(a) Suppose that you are the Californian government, that you care equally about tax revenue for Santa Monica and UCLA's profits, and that you can regulate UCLA's decision to use the Interceptor. Define the first-best outcome. How should you regulate UCLA?

Solution: The benefits of using the Interceptor 007 to stop pollution ($2 million tourism revenue) exceed the costs ($100,000), so the first-best outcome is to deploy the Interceptor to protect the Bay. This implies regulation should mandate that UCLA use the Interceptor to stop pollution.

(b) Now suppose that the Californian government cannot regulate, tax, or subsidize UCLA. Using concepts discussed in class, when, if ever, will the first-best outcome occur?

Solution: It will not occur if UCLA maximizes profits and the City cannot contract with UCLA. But we have assigned property rights (to UCLA) and UCLA maximizes profits. If in addition, contracting involves no transaction costs, the City of Santa Monica maximizes tax revenue, and both UCLA and the City of Santa Monica have full information, then the Coase theorem will apply, and the first-best outcome should arise.

(c) It turns out that using the Interceptor will also increase the sea lion population. Sea lions can be a nuisance. In particular, they attract sharks that endanger surfers. A surfer association, which represents these surfers, has estimated that the costs of anti-shark protection measures due to the new sea lions would be approximately $500,000.

How does this new information change your answers to (a) and (b), assuming that the Californian government cares as much about surfers as it cares about UCLA and the City of Santa Monica?

Solution: For (a), the answer should not change, because $2 million is still greater than the combined cost (now $\$100,000 + \$500,000 = \$600,000$).

For (b), the first-best outcome can arise when the Coase theorem applies as discussed. In addition, if the assumptions above apply to the surfer association, rather than the City of Santa Monica, then we will reach the efficient outcome.