Name: ____________________
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Economics 134 Fall 2025 Midterm 1 – Solutions

October 27, 2025

Write your name and UID in the upper right corner of each page.

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

QUESTION 1 (40 points). Coffee.

(a) Zach is brewing coffee. To make q quarts of coffee, he incurs costs equal to $6q^2$. He can sell the coffee for \$6 per quart. If Zach maximizes his profits, how much coffee will he make? Calculate his profits.

Solution: $\pi(q) = 6q - 6q^2$, so $\pi'(q^*) = 6 - 12 \cdot q^* = 0$ implies that $q^* = \frac{1}{2}$ quart of coffee.

He will make $\pi(q^*) = 6 \cdot q^* - 6 \cdot (q^*)^2 = 6 \cdot \frac{1}{2} - 6 \cdot \frac{1}{4} = \frac{3}{2}$.

(b) Luci lives upstairs from Zach and can smell the coffee through her window. She incurs $D(q) = 6q^2$ of damage. How much is she willing to pay to make sure that Zach makes no coffee?

Solution: She is willing to pay up to $D(q^*) - D(0)$, or $6 \cdot \left(\frac{1}{2}\right)^2 = \frac{3}{2}$.

(c) What is the efficient (or "first-best") level of coffee production?

Solution: $W(q) = 6q - 6q^2 - 6q^2 = 6q - 12q^2$, so $W'(q^{\mathrm{FB}}) = 0$ can be written here as $6 - 24q^{\mathrm{FB}} = 0$, or $q^{\mathrm{FB}} = \frac{1}{4}$.

(d) If Zach must give Luci \$3/quart for the coffee that he makes, is the outcome efficient?

Solution: Yes. The optimal or Pigouvian tax is $\tau = D'(q^{\mathrm{FB}})$, and since $D'(q) = 12q$, the optimal tax is $12 \cdot \frac{1}{4} = 3$. So we are charging Zach the Pigouvian tax, and therefore will arrive at the efficient outcome.

Alternatively, we could solve $\max_q [\pi(q) - 3q]$ directly, and note that we obtain the same answer as (c).

(e) How would your answer to (d) change if the price for which Zach can sell the coffee rises to $12 per quart?

Solution: The outcome is no longer efficient because the $3/quart no longer guarantees the first best. The tax is still $D'(q^{\mathrm{FB}})$, but the first-best level of coffee production has changed, to $\max_q \left[12q - 6q^2 - 6q^2\right]$ or $12 - 24q^{\mathrm{FB}} = 0$, or $q^{\mathrm{FB}} = \frac{1}{2}$.

The optimal tax is now $D'(q^{\mathrm{FB}}) = 12 \cdot \frac{1}{2} = 6$.

QUESTION 2 (20 points). Wolves.

Drivers often collide accidentally with deer on roads in rural areas. On average, a deer-vehicle collision costs $10,000 in repairs and other harm.

Recently, some economists in Wisconsin have learned that efforts to reintroduce gray wolves have lowered the number of deer-vehicle collisions by an average of 24%. (Wolves eat deer; many deer also anticipate being eaten and move elsewhere.)

Wolves also eat farmers' livestock, with the efforts to reintroduce wolves estimated to cost $174,000 per year in terms of livestock lost to wolves.

a) Do the wolves create negative externalities? Positive externalities? Explain.

Solution: The wolves have positive externalities on drivers because they lower the probability of damaging collisions. The wolves have negative externalities on farmers because they may eat the farmer's livestock.

b) Assume that the only cost of wolf repopulation is livestock damage and that the only benefit is avoided deer-vehicle collisions. Prior to the wolves, there were about 4,600 deer-vehicle collisions in Wisconsin per year. What is the approximate annual net benefit of reintroducing the wolves?

Solution: $(0.24 \cdot 46 \cdot 10^6) - 174000 = 10.8$ million

c) Given your answer in (b), would you recommend wolf repopulation if it is possible to transfer resources between drivers and farmers?

Solution: Yes; it creates significant net benefits and they can be used to compensate the farmers for their lost livestock.

d) In terms of the protection that they provide against deer-vehicle collisions, are the wolves discussed in this question an example of a "public good"? Explain.

Solution: Yes. There is zero marginal cost of providing additional protection to additional drivers, so the benefit of wolf protection against deer is nonrivalrous. In addition, we cannot exclude people from benefitting fully from this protection, so it is nonexcludable. Hence wolf protection against deer collision is a public good.

QUESTION 3 (25 points). Oil refining.

As mentioned in lecture, the oil refinery in El Segundo produces 270,000 barrels of oil per day.

(a) Suppose that the profits of the oil refinery are given by $\pi(q) = 27q - \frac{1}{2}q^2$, so that the oil refinery produces $q^* = 27$ when it maximizes its profits.

Further suppose that we have discovered marginal damages from the oil refinery to the surrounding community, equal to $D'(q) = 8q$, in the same units as the profit function.

Calculate the optimal Pigouvian tax that we could charge the oil refinery so that it lowers its production to the first-best.

Solution: The Pigouvian tax equals $\tau = D'(q^{\text{FB}})$. We already have $D'(\cdot)$, but we need to find the first-best q^{FB}. Here, this will satisfy our formula in lecture,

$$\pi'(q^{\text{FB}}) - D'(q^{\text{FB}}) = 0,$$

which gives us $27 - q - 8q = 0$, or $q^{\text{FB}} = \frac{27}{9} = 3$.

So, the optimal tax is $\tau = D'(q^{\text{FB}}) = 8 \cdot 3 = 24$ per unit of output.

(b) Without doing any exact calculations, explain how one could calculate the distributional effects from requiring that the refinery pay the tax in (a), relative to a free market where the refinery can freely choose what to produce.

Solution: Distributional effects on the refinery are its lost profit moving from q^* to q^{FB} as well as the tax paid (unless some share of the tax paid is reimbursed lump-sum to the refinery). With a calculator, one could evaluate the exact expression for lost profits,

$$\pi(q^*) - \pi(q^{\text{FB}}) = \left[27 \cdot 27 - \frac{1}{2} \cdot 27^2\right] - \left[27 \cdot 3 - \frac{1}{2} \cdot 3^2\right],$$

and also think about the total tax paid, which equals $R = 24 \cdot 3 = 72$.

The effects on the neighboring community would require that we integrate marginal damages from q^* to q^{FB} (and then add any tax revenue the community receives). If we wanted the full calculation, it would be $\int_3^{27} 8q dq = 4q^2\big|_3^8 = 4 \cdot 64 - 4 \cdot 9 = 4 \cdot 55 = 220$.

(c) Suppose that we cannot levy any taxes on the refinery. Provide another policy that could attain the same first-best outcome as (a), without necessarily having the same distributional outcomes.

Solution: Quantity regulation. Require $q \leq q^{\text{FB}}$, i.e., $q \leq 3$. Unless we rebate all of the tax revenue lump-sum to the refinery, the distributional outcomes will differ.

QUESTION 4 (15 points). Vermont.

You have obtained detailed data on the location, size, and price of every house in an isolated county in Vermont in 2010 and in 2020. You also know that between 2014–2017, the county restored several thousand acres of forests.

a) State the assumption(s) needed to apply implicit (hedonic) price theory to estimate the value of forest conservation for homeowners in this county from this data.

Solution: The necessary assumption is that the houses between 2010 and 2020 are identical in every characteristic except the presence of the forest.

b) If housing prices increased from 2010 to 2020, should we infer that the county's residents assigned a positive value to the forest restoration? Why or why not?

Solution: Not necessarily, unless the assumption in (a) is satisfied. For example, there could be a third factor (an omitted variable) changing housing prices and driving forest restoration.

c) Would your answer to (b) change if you learned that this county's forest restoration project had taken place due to its receipt of an experimental grant from a U.S. Forest Service program that had randomly funded restoration in some—but not all—similar counties? Assume that, over 2010–2020, housing prices did not change for counties that did not receive grants.

Solution: Yes; this creates true experimental variation, and the control group did not see the same increase in housing prices.