

Economics 134 Fall 2024 Midterm 1 – Solutions

October 21, 2024

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 (70 points). The Great Pumpkin.

Charles is trying to grow a large pumpkin, specifically of size q . His profits from the pumpkin will be $\pi(q) = 9q - q^2$.

(a) When Charles is free to grow a pumpkin as large as he wants, what size pumpkin will he grow? Assume Charles maximizes his profits.

Solution: $\pi(q^*) = 0$ or $9 - 2q^* = 0$, so $q^* = \frac{9}{2}$.

(b) Charles lives next door to a family with small children. The larger Charles' pumpkin, the scarier it is. Specifically, the children are scared by the pumpkin according to the damage function $D(q) = 3q^2 - q$. If Charles maximizes his profits, how scary will his pumpkin be?

Solution: $D(q^*) = 3(q^*)^2 - q^* = 3 \cdot \frac{81}{4} - \frac{9}{2}$.

(c) If the utility of the children, $-D(q)$, is in the same units as Charles' profits, what size pumpkin maximizes total surplus?

Solution: Maximizing $\pi(q) - D(q) = 9q - q^2 - 3q^2 + q = 10q - 4q^2$ with the first-order condition $0 = \pi'(q^{FB}) - D'(q^{FB}) = 10 - 8q^{FB}$ or $q^{FB} = \frac{5}{4}$.

(d) What per-unit tax on Charles' pumpkin will attain the outcome you calculated in (c)? Calculate the distributional effects on Charles of imposing the tax.

Solution: $\tau = D'(q^{\text{FB}}) = 6q^{\text{FB}} - 1 = \frac{30}{4} - 1 = \frac{13}{2}$ per unit size of the pumpkin.

The distributional effects will be the change in profits,

$$\pi(q^{\text{FB}}) - \pi(q^*) = [9q^{\text{FB}} - (q^{\text{FB}})^2] - [9q^* - (q^*)^2] = \left[9 \cdot \frac{5}{4} - \frac{25}{16}\right] - \left[9 \cdot \frac{9}{2} - \frac{81}{4}\right] = \frac{45}{4} - \frac{25}{16} - \frac{81}{4},$$

combined with what we do with the revenue of $R \equiv q^{\text{FB}} D'(q^{\text{FB}}) = \frac{5}{4} \cdot \frac{13}{2}$.

If we give it to the children, Charles also loses the tax payments, and will get $\frac{45}{4} - \frac{25}{16} - \frac{81}{4} - R$.

If we rebate it all to Charles (lump-sum), Charles will get $\frac{45}{4} - \frac{25}{16} - \frac{81}{4}$.

(e) Suppose the children have the right to dictate how large Charles can grow the pumpkin (because their mother is a federal judge). If Charles offered the neighbor's children 10 utils worth of candy to be allowed to produce a pumpkin of any size, would they accept his offer?

Solution: If Charles can produce any pumpkin size, he will produce $q^* = 9/2$, from (a). The loss to the children will be $3 \cdot \frac{81}{4} - \frac{9}{2} = 60 + \frac{3}{4} - \frac{9}{2} > 10$. So the children will not accept the offer.

(f) Will the offer in (e) lead to a Pareto improvement relative to the case in which the children prohibit Charles from growing any pumpkin at all?

Solution: No. The children will not accept Charles' offer, so Charles will not be allowed to grow his pumpkin. Therefore, no one is made strictly better off from the offer.

Note that an alternative, subtler answer is that, while children will not accept Charles' offer, under the assumptions of (e), they can require that he produce a small, optimally scary pumpkin. That pumpkin will maximize $-D(q) = q - 3q^2$, at $\tilde{q} = 1/6$, which also improves Charles' payoffs. So both participants would be better off relative to the complete pumpkin prohibition, making (e) a Pareto improvement.

(g) Suppose, instead, that Charles has the right to choose how large a pumpkin he can grow. What is the most that he can demand from the children to produce the first-best pumpkin size in (c)?

Solution: He can ask for up to $D(q^*) - D(q^{\text{FB}})$, or $D(\frac{9}{2}) - D(\frac{5}{4}) = 3 \cdot (9/2)^2 - 9/2 - [3 \cdot \frac{25}{16} - \frac{5}{4}]$, which equals 52.8125 (plug into a calculator or leave the scary expression as is!).

- (h) Charles has just learned that he has to participate in an extremely boring school play, creating uncertainty over how costly it will be for Charles to grow his pumpkin. To maximize total surplus, should we mandate that Charles produce a pumpkin of exactly the first-best size in (c)? Or instead impose the tax in (d)?

Solution: It depends whether we are more worried about the uncertainty about the scariness of the pumpkin for the children or the uncertain cost Charles needs to incur.

Charles' cost function's second derivative is $c''(q) = 2$ and the second derivative of the damage function is $D''(q) = 6$, which means (according to Weitzman 1973) we prefer that Charles produce a pumpkin of fixed size.

QUESTION 2 (20 points). True or False.

- (a) In lecture, we discussed how Greenstone's (2002) estimate of the number of jobs lost because of the Clean Air Act between 1972–1987 was much larger than the actual decline in U.S. manufacturing employment during that period.

Solution: True.

- (b) After we passed the Clean Water Act in 1972, on average across the United States, water quality stopped improving as rapidly as it had in the past.

Solution: True.

- (c) As long as equilibrium house prices are determined taking into account homeowners' value for local air pollution, we can use the correlation between home prices and local air pollution to measure the welfare costs of air pollution to homeowners.

Solution: False. We need to be careful about controlling for other omitted variables before we can use the data on home prices and local air pollution.

- (d) Because pumping water from a groundwater aquifer depletes the remaining water for other users, groundwater is not a public good.

Solution: True. This fact makes groundwater rivalrous (a common-pool resource), but public goods must be nonrivalrous.

QUESTION 3 (20 points). Hotelling Home Repair.

For parts (a)–(c), suppose that there are two people, A and B.

Person A knows how to plant trees. Person A's house has a nice tree, but needs to be repainted.

Person B knows how to paint houses and already has a nicely-painted house. Person B likes trees, but has no tree.

Assume that planting trees and painting houses requires work, but that the utility of having a nicely-painted house or a tree exceeds the disutility of the work.

(a) Suppose we make person A plant a tree in front of person B's house. Is this a Pareto improvement? Explain.

Solution: No. A is worse off.

(b) Suppose we make person B paint person A's house. Is this a Pareto improvement? Explain.

Solution: No. B is worse off.

(c) If person A plants a tree for person B, and person B paints person A's house, is this a Pareto improvement? Explain.

Solution: Yes. A and B are both strictly better off.

(d) Suppose that we move the worst UCLA football player to USC, and the quality of both teams goes up. Is this a Pareto improvement? Explain.

Solution: No, the UCLA football player has to play at USC. Assuming that they preferred to be at UCLA, someone is worse off.

There are many other ways to answer this question, of course. For example, if someone prefers that USC have a worse team, this would not be a Pareto improvement.