Economics 134 Problem Set 1 – Solutions

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1. What is the definition of a negative externality? Give an example not from lecture.

Solution: For the definition, see slide 22 of Lecture 1.

2. Rabbits are everywhere! They are destroying gardens, but many people find them to be cute.

(a) Suppose that there are six prospective rabbit owners, each of whom can adopt one rabbit for free. Each prospective rabbit owner derives 4 units of utility from having a rabbit, and none have gardens. How many rabbits will prevail if prospective rabbit owners can freely adopt rabbits?

Solution: Each prospective owner will adopt a rabbit, so there will be 6 rabbits.

(b) Suppose that we care about the total utility of the six rabbit owners given in part (a), minus the total cost of garden repairs, which equals $c(r) = \frac{1}{3}r^3$ for r rabbits. How many rabbits should we allow to be adopted?

Solution: Total utility net of costs is $4r - c(r)$, which is maximized at $4 - r^2 = 0$, or two rabbits.

(c) What general economic concept from lecture does this silly example illustrate?

Solution: Rabbit-owning has negative externalities.

3. There were 275,924,442 vehicles registered in the United States in 2020.

(a) Give an example of an externality associated with an additional driver on a congested road.

Solution: Congestion! Additional drivers will slow down traffic for everyone; congestion has various social costs, for example, in terms of others' time (and time is money, as we know).

(b) How can tolls help alleviate this externality? When will a toll booth be Pareto efficient?

Solution: (i) Tolls raise the cost of driving and will incentivize the marginal driver to carpool or otherwise avoid driving; this alleviates the congestion externality for the remaining drivers.

(ii) Introducing a toll booth will be Pareto efficient if it makes no one worse off and at least someone is better off. This could be the case if, for example, the toll booth lowers congestion by so much that even though everyone pays a little bit, each person values the reduction in congestion more than the inconvenience of paying the tolls or changing one's driving route. But if the tolls cause even just one person to stop driving (because, for example, they cannot afford the toll), then introducing a toll booth will not be a Pareto improvement.

(c) How should the toll be set?

Solution: The optimal toll should equal the marginal social cost of the additional driver, measured in terms of congestion. In general, the optimal toll should vary based on the extent of existing congestion. When the additional car is likely to slow down traffic significantly, the toll should be high.

(d) Some cities (e.g., Beijing during the 2008 Olympics) restrict the total quantity of cars, by banning cars with even (or odd) last digits of their license plates on alternating days. Why might this be preferable to the optimal toll in (c)?

Solution: Such cities might care about distributional outcomes. If you charge a toll, then some high-income people will always drive and some low-income people may be unable to drive at all. However, if you restrict the quantity by alternating between even and odd license plate digits, you may still attain the same total number of cars on the road (which determines the congestion externality), but the cost of the policy is more evenly distributed across people.

Another reason might because the Beijing authorities were uncertain about drivers' costs of not driving. Then they may have preferred fixing the total quantity of cars on the road to avoid a dangerous threshold to letting a price determine the eventual level of the aggregate externality, for the price-versus-quantity reasons discussed in Lecture 3 (slides 7–9).

4. Teresa lives in a house and produces music.

(a) Suppose that Teresa's cost of producing q units of music is given by $c(q) = \frac{1}{2}q^2$. She can sell her music to her friends Daniel and Martin for a per-unit price of $p = 8$. Assuming that Teresa maximizes her profits, given by $\pi(q) = 8q - c(q)$, how much music will Teresa produce? How much money will she make?

Solution: Teresa maximizes $8q - c(q)$, i.e. she solves $\frac{\partial \pi}{\partial q} = 0$ or $8 - q = 0$, so she will produce 8 units of music.

(b) Why might we call the answer to (a) the "free market" outcome?

Solution: Because Teresa is freely maximizing her profits in the market.

(c) Teresa's grandmother also lives in the same house. Suppose that she dislikes Teresa's music. When will it be a Pareto improvement for her to prohibit Teresa from producing music? Assume that Teresa's grandmother cannot transfer any money or utility to Teresa.

Solution: It will never be a Pareto improvement because Teresa is made worse off without her music.

(d) Now suppose that Teresa's grandmother can pay Teresa to produce less music, that she suffers $D(q) = \frac{3}{2}q^2$ per unit produced, and that she values money in the same units as her utility. How much will she be willing to pay to stop Teresa from ever producing any music? Will Teresa accept her highest offer?

Solution: Teresa's equilibrium music production is $q^* = 8$. Her grandmother is willing to pay up to $\frac{3}{2}(q^*)^2 = \frac{3}{2} \cdot 8^2 = 96$. Teresa's profits are 32, so she will accept the offer.

(e) Suppose now that Teresa's grandmother has the right to stop Teresa from ever producing music, but she can also give Teresa permission to produce some level of music $\tilde{q}$ in exchange for some of the profits. What level of music production should she specify?

Solution: The first-best allocation solves $8 - q - 3q = 0$ or $q^{\text{FB}} = 2$

(f) Why do we call the answer to (e) the "efficient" or "first-best" allocation?

Solution: Because it maximizes social surplus.

(g) Suppose instead that Teresa's grandmother can charge Teresa a tax τ per unit of music produced, and that she maximizes the sum of her utility and Teresa's profits. What tax should she charge?

Solution: The marginal social cost, $3q$, evaluated at the first-best outcome, so she should charge a tax of 6 per unit.

(h) Suppose that Teresa's grandmother can buy a pair of fluffy earmuffs that completely eliminate her suffering from Teresa's music. Suppose that the cost of buying these earmuffs is given by $\frac{3}{2}q^2$ (the earmuff store charges more when Teresa produces more music). Does this solve the externality?

Solution: No, there is still an externality. Even though Teresa's grandmother buys the muffs, this is still a cost that she incurs because of Teresa's behavior. Adaptation costs are still economic costs!

(i) Suppose the fluffy earmuffs are available for sale as in part (h), and that Teresa and her grandmother have incorporated into a single firm, sharing the profits from her music net of the production and earmuff costs. Will they coordinate on the efficient level of music?

Solution: Yes. (See slide 21 of Lecture 3.)

(j) Teresa's neighbor loves music and particularly enjoys hearing the sound of Teresa's music production through their windows. Without doing any math, discuss how this might change the efficient level of Teresa's music production.

Solution: This is a positive externality! It should increase the efficient level of music production.

5. Zoning laws, which restrict how individuals use their land, are sometimes justified as a means of controlling externalities. How might they work? Give an alternative solution to one such externality. What is one distributional effect of a zoning law?

Solution: There are various ways to answer this question. Here is one:

Land use involves many external effects, such as

- affecting the aesthetic quality of the surrounding neighborhood (e.g., parks allow for recreation; buildings can be ugly or block sunlight from neighboring buildings)
- creating congestion (e.g., businesses draw workers and customers who may create noise or occupy parking spots)
- altering the dangers of natural disasters (e.g., wetlands can provide flood protection).

Zoning limits the use of certain areas to certain types of land use. For example, zoning regulations might specify park boundaries, require the preservation of historical buildings, ban new construction in certain areas above a certain height, prevent business establishments from operating in residential areas, or prohibit wetlands destruction without permitting. Zoning rules therefore operate as a kind of quantity regulation to correct for these externalities.

Alternative solutions to these externalities include the policies discussed in class. A Pigouvian tax might subsidize attractive buildings or wetland conservation. Defining property rights and allowing trade could, for example, involve allocating property rights for airspace above buildings. Mergers among homeowners might also allow the resulting cooperative to internalize some of the externalities (e.g., gated communities).

Distributional effects can be especially important for zoning laws given that zoning can affect landowners differently from prospective renters or developers. For example, some zoning laws reserve lots for single-family homes, motivated in part by concerns with aesthetic or congestion externalities arising from larger housing developments. Such zoning laws can raise the price of homes in a neighborhood, which will have different distributional outcomes: existing homeowners will benefit, but renters will suffer if the lower housing supply raises rental prices.

6. We have obtained data on the number of whales seen off the coast of a certain Hawaiian island in each month from 2010–2020. The only business establishment located on this coast is a hotel, The White Lotus. We have also obtained records about its total revenue and number of guests in each month from 2010–2020.

(a) Briefly explain how this data might be used to learn about the value of whale conservation.

Solution: There are various ways to answer this question. The general idea is that the correlation between economic activity at The White Lotus and whale sightings off the coast can be informative about the guests' value of (willingness to pay for) the whales, if guests are more likely to visit (and/or willing to pay more per visit) when they expect to see more whales. One could, for example, regress monthly revenue or visitors on monthly number of whales, controlling for the month and the year.

(b) Give some reasons why this data may be ill-suited for the question in (a).

Solution: There are several concerns. Here are some:

- Omitted variables may affect both the number of whales and revenues or number of guests of The White Lotus. For example, whales are most often seen in Maui between January and March, which happen to be some of the rainiest months. In this case, a negative correlation between the number of whales seen and the number of guests at The White Lotus could simply reflect the fact that fewer people like to visit when it is raining.
- Reverse causality is also possible. For example, more guests might increase the number of whale sightings, even while the true number of unique whales remains constant. Valuing whale conservation requires that we answer the causal question of how much people might be willing to pay to conserve additional whales in the ocean.
- Whales have many values. The "value of whale conservation" surely encompasses more than just the value for the guests at The White Lotus. Whales travel very long distances and may say hello to various people around the world. For example, future generations may value whales, but they have not yet been able to visit The White Lotus.

(c) What additional data or information could be helpful?

Solution: There are various ways to answer this question. Here are some:

- Additional controls for variables that might correlate with both the number of whale sightings and the number of visitors could be helpful to reduce concerns with omitted variable bias; for example, data on monthly weather, visibility, and temperature from 2010–2020.
- Other variables (e.g., conservation policies) that shift the number of whales without affecting the unobserved determinants of the number of visitors and revenue at The White Lotus could also be helpful in identifying the causal relationship.
- Additional information about other economic outcomes related to whales, such as tourist activity in other places where the same whales travel, or details about the role that whales play in sustaining broader ecosystems, could help.