Intermediate Microeconomics – Spring 2025

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Problems Set 4

Due Wednesday May 21st

Instructions:

1. You can either write down your answers by hand or type out your solutions. Please hand in a hard copy of your answers and make sure your work is stapled. Alternatively, you can submit a digital copy to the TA via email. Most importantly, please remember to indicate your name and student number on your homework.

2. The problem sets should be submitted to the TA before the beginning of the lecture on the due day. Late submissions will NOT be accepted. If you have any emergency that prevents you from coming to the lecture, please email an electronic version of your problem set to the TA before the class.

3. You are encouraged to discuss with your classmates, but please write down your answers individually. Directly copying others' answers may result in zero points.

Question 1: Externality

Consider a plant that manufactures dynamite d and a nearby farm producing tomatoes t. The dynamite's production cost is:

$$TC_d(d,x) = (\frac{1}{2})d^2 + (x - 2)^2$$

where d is the amount of dynamite produced and x is the intensity of use of nitrogen in the production process. The side product associated with use of nitrogen is NH_3- a fertilizer that is released to the air. Such fertilizer promotes growth of tomatoes, making the production cheaper. In particular, the higher the intensity x, the lower is the farmer's cost:

$$TC_t(t,x) = (\frac{1}{2})t^2 + 2t - xt$$

The prices of tomatoes and dynamite are: $p_d = p_t = 1$.

a. Is the market interaction associated with a positive or negative externality?

b. Find the level of production of dynamite *d* and intensity *x* that maximizes the profit of the dynamite manufacturer. What is the maximum level of profit?

c. What is the marginal benefit from using *x* in optimum? Give one number and show it on the graph with *x* is on the horizontal axis.

d. Given the intensity *x* from part (b), find the optimal level of production of tomatoes *t*, and the profit of the farmer.

e. Find the joint profit of the dynamite manufacturer and the farmer.

f. Find the **pareto efficient** level of production of *d*, *t* and use of nitrogen *x*. Compare these values to the ones obtained in parts b) and d).

g. Is the marginal benefit from using *x* in f) positive, zero, or negative? Why?

Question 2: Taxing pollution

Buchanan Industries receives total benefit/profit from polluting according to the formula:

$$\pi = 10Q - Q^2$$

where Q = pollution emitted (in tons), and profits are measured in dollars. The total costs/damages associated with pollution from this facility are estimated to be:

$$D = Q^2 + 2Q$$

(a) Draw a graph of both the marginal benefits and marginal damages from pollution curves, labeling all axes, intercepts, and slopes.

(b) If Buchanan Industries does not have to pay for the damage its emissions cause:
- How much Q would it produce?
- How much profit would it earn at this level of production?
- How much would its total damages be?
- What would be the net benefits (i.e., difference between profits and damages)?

(c) What is the socially efficient level of Q for this firm? How much profit would Buchanan Industries earn at this level of production? How much would total damages be? What would be the net benefits?

(d) What is the deadweight loss associated with Buchanan Industries ignoring the damages that its production causes? Show the deadweight loss on your diagram.

(e) Those who live near Buchanan Industries propose that it produce no more than $Q = 1$. What is the deadweight loss associated with this level of production? Show this DWL on your graph.

(f) Who benefits from reducing Q from the initial level in (b) to the efficient level in (c)? Who bears the costs? Is this change Pareto improving or could it be a potential Pareto improvement (say after transfer/compensation)?

Question 3: Monopoly

PineApple Company decides how many packets of the new operating system it is going to sell on the market. The research (fixed) costs associated with the development of the new system amounts to F = \$1000. The variable costs of the packet is negligible, variable cost = 0. PineApple's inverse demand for the new operating system is given by

$$p(y) = 100 - y$$

a. What would consumer and producer surplus be if PineApple was a price taker (a competitive firm)? Give exact numbers and show corresponding areas on a graph.

b. Assume that PineApple is a monopoly, and it cannot discriminate among its customers. Find geometrically and analytically the level of sales that maximizes profit, the market price, and the maximum profit.

c. Is outcome in (b) *pareto efficient*? If not, find the deadweight loss (*DWL*) geometrically and analytically.

d. Find consumer's and producer's surpluses (*CS* and *PS*) geometrically and analytically, with a monopolistic firm.

e. Find the elasticity of the demand at the optimal level of production. Is the monopolistic firm operating on elastic or inelastic part of the demand?

f. Suppose that PineApple can perfectly price discriminate among the consumers. What is PineApple's profit if in that case? Is the allocation *pareto efficient*? What is consumer surplus?

Let's get more realistic and assume that PineApple can charge different prices on two segments of the market: individual buyers and firms. The demands on two segments are:

$$y^I(p^I) = 50 - \frac{4}{5}p^I$$

$$y^F(p^F) = 50 - \frac{1}{5}p^F$$

g. Find the level of sales, price, profit and elasticity of demand for each segment of the market.