

EC371 – Environmental Economics

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Practice Problems for Unit 1: Markets, Efficiency and Market Failure

There are three problems. Please read and think about them carefully, and work through them before looking at the solutions. If you are having trouble, you can seek clarification and help from classmates and during my office hours, but it is highly recommended that you struggle through the questions yourself first. Your goal should be both to learn the mechanics and to grasp the intuition and think more deeply about the issues. Solutions will be posted around the afternoon of Thursday, September 29. If you would like comments on your work and solutions, you can submit them to me at any time.

1. Consider an economy with two goods, x and y . Denote the price of x as p and set the price of y to 1. There are two consumers, A and B, who have the utility functions $u^A(x^A, y^A) = 10y^A - 0.2(250 - x^A)^2$ and $u^B(x^B, y^B) = y^B - 0.08(62.5 - x^B)^2$ respectively. The aggregate marginal cost curve for producing good x in this economy is given by $MC = 4 + 0.016Q$ where Q is the aggregate quantity of good x . All markets are perfectly competitive, and all of the standard assumptions hold.

a) Find consumer A's demand function for good x (i.e. an expression relating A's consumption of x to p). Find consumer B's demand function for good x as well. (Hint: recall the condition for constrained individual utility maximization from your 201 class or look it up, and note that $MRS^A = 0.04(250 - x^A)$, while $MRS^B = 0.16(62.5 - x^B)$ in this case. You do not have to know how to derive MRS.)

b) Find the aggregate demand function for good x . Verify that the market equilibrium quantity is 125 units and find the associated equilibrium price. Draw a graph showing the aggregate demand and supply curves for good x . Be sure to label your axes, curves, intercepts and equilibrium price and quantity and get the shapes of the curves correct, but don't worry about precise scale.

c) Find the economy-wide marginal benefit and marginal cost of the 19th unit consumed/produced. If there were currently 19 units being consumed/produced, would it be good for the economy to decrease consumption/production to 18 units? Explain why or why not.

d) Calculate total net benefits associated with the equilibrium quantity, the equilibrium quantity plus ten units and the equilibrium quantity minus ten units. (Note that calculating total costs is a bit trickier than it was with the example from class, since the marginal cost curve does not go through the origin in this case. Drawing a graph might help with these calculations.) Based on these calculations, does it appear that the market equilibrium is an efficient outcome? Explain.

2. Suppose that a wood pulp mill is situated on a bank of the Charles River. The private marginal cost (MC) of producing wood pulp (in \$ per ton) is given by $MC = 1.875Y$ where Y is tons of wood pulp produced. In addition to the private marginal cost, an external marginal damage (MD) is incurred due to harm from pollutant flows into the river, valued at $6.25 + 1.25Y$, in \$ per ton. This external cost is borne by the wider community, not by the polluting firm in isolation. Even though we are concerned with a single mill, it behaves perfectly competitively. The aggregate inverse demand curve for wood pulp, in \$ per ton, representing both the private and social marginal benefits (MB), is given by $MB = 100 - 3.125Y$.

a) Calculate the marginal social cost (MSC) curve and draw a diagram illustrating the MC, MB and MSC curves. (Be fairly precise with the graph: label your axes, intercepts and curves; don't worry too much

about getting the scale perfect, but do make sure the shapes, positions and slopes of the curves are roughly correct in relation to one another.)

b) Find the market equilibrium quantity of wood pulp in tons, i.e. the quantity that maximizes total private net benefits. Find the socially efficient pulp output, i.e. the level that maximizes total social net benefits. Explain why you would expect one of these output levels to be larger than the other. (You should get nice round numbers for these quantities, and the difference between them should be five units.) Calculate the efficiency loss that would be suffered if the market rather than the efficient quantity were produced.

c) Calculate the Pigouvian per-unit tax to be collected from the mill that would achieve the socially efficient output level. Calculate the tax revenue that would be generated by implementing this tax.

d) Suppose that, instead of putting the tax policy in place, the Massachusetts government determines that the wood pulp mill has the right to pollute the river as much as it wants to, and commits to legally enforcing that right. Is it theoretically possible to achieve social efficiency in this situation without any further government involvement? Do you think efficiency would likely be achieved in reality?

3. A group of northeastern states is conducting research on auction designs for a regional carbon dioxide cap-and-trade system. The marginal costs for conducting such research are flat, at \$31 per month in thousands of dollars. The marginal benefits enjoyed by the region are derived from the grants they receive as well as the usefulness of the results, and depend on how much research is being done: $MB = 50 - 0.5Q$, where Q is months of research done in the group of northeastern states and MB is measured in thousands of dollars. There are three other states or groups of states that are also considering implementing a cap-and-trade system: California, a group of southern states and a group of western states. These states enjoy some benefit from the research done by the northeastern states, since those research findings can partially inform the auction design process for any region. If they could buy months of research done by the northeastern states for some price p (in thousands of dollars per month), their demand curves would be $q^c = 100 - 20p$, $q^s = 100 - 10p$ and $q^w = 100 - 8p$ for California, the southern states and the western states respectively, where q^i refers to the number of months of research done by the northeastern states demanded by state/region i .

a) Think of the research done by the northeastern states as a public good. Find the aggregate marginal willingness to pay relation for this research amongst the three state/regions aside from the northeastern region.

b) Now think of the research done by the northeastern region in terms of a positive externality. Call the marginal willingness to pay relation derived in part a) the marginal external benefit (MEB), and use this to find a marginal social benefit (MSB) relation encompassing the marginal internal benefits and the marginal external benefits arising from research done by the northeastern region. Calculate the amount of research that will be done if the northeastern region acts in its self interest. Calculate the amount of research that is efficient from the perspective of all four state/regions. Give some intuition for why the efficient outcome is higher than the self-interest outcome. (You should get 60 for the socially efficient level. Be careful when converting the verbal description of MC into mathematical form.)

c) Suppose that the federal government decides to offer a subsidy to the northeastern region to try to increase the amount of research done. Find the appropriate per-unit Pigouvian subsidy that will achieve the efficient amount of research. Calculate the total subsidy amount that the federal government will disburse to the northeastern region with this policy in place. Calculate the associated efficiency gain.