University of Macedonia
Department of Economics

Natural Resource Economics

Instructor: Eftichios Sophocles Sarzetakis
Communication: Office # 206, Telephone # 891680, Email: esartz@uom.edu.gr
Office hours: Tuesday and Thursday 12:00 - 14:00 or by appointment.

1. Exercise in Natural Monopoly pricing

Assume that a certain natural monopolist has the following demand and cost related curves:

Demand:	$P = 100 - Q$
Total Revenue:	$TR = PQ = 100Q - Q^2$
Marginal Revenue:	$MR = \partial TR/\partial Q = 100 - 2Q$
Total Cost:	$TC = 400 + 15Q$
Average Cost:	$AC = 15 + (400/Q)$
Marginal Cost:	$MC = \partial TC/\partial Q = 15$

a. Graph all the above curves.
b. Explain why the above market is a natural monopoly.
c. If the market is served by an unregulated monopoly, find quantity supplied, price and profits of the monopolist. Find also the dead-weight loss associated with monopoly pricing.
d. If marginal cost pricing is imposed, find quantity supplied and profits of the regulated monopolist. Will the regulated monopoly stay in the market in the long-run? How can the government convince the monopolist to stay in the market?
e. If average cost pricing is imposed, find quantity supplied, price and profits of the regulated monopolist. What are the potential problems of average cost pricing?
f. If the regulator allows the natural monopoly to charge a two-part tariff, with the per unit fee equal to MC, what would the entry fee be if there are 50 customers in the market?

2. Homework for Natural Monopoly pricing

Assume that the market for electricity is a natural monopoly. The utility faces the following market demand: $P = 140 - Q$. The utility's total cost of production is: $TC = 575 + 20Q$.

i. Find the Marginal Revenue (MR), Average Cost (AC) and Marginal Cost (MC) functions. Graph all these functions (including the Demand). *[Hint: In order to graph the AC curve, find the points in which the AC curve intersects with the Demand curve. Remember that the roots of a quadratic equation* $ax^2+bx+c=0$*, are given by the quadratic formula* $x_{1,2} = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$*.]*

ii. Explain why the above market is a natural monopoly.

iii. If marginal cost pricing is imposed, find quantity supplied, price and profits of the regulated monopolist.

iv. If the market is served by an unregulated monopoly, find quantity supplied, price and profits of the monopolist. Calculate also the dead-weight loss associated with monopoly pricing

v. If average cost pricing is imposed, find quantity supplied, price and profits of the regulated monopolist. What is the deadweight loss associated with average cost pricing? Calculate it mathematically and show the corresponding area in the graph.

vi. If the regulator allows the natural monopoly to charge a two-part tariff, with the per unit fee equal to MC, what would the entry fee be if there are 25 customers in the market? (Assuming that the profits will be zero).

Exercise in peak load pricing

Exercise 1

We assume that peak and off-peak periods have equal length (12h a day). The demand during off-peak period is: $P_o=60-0,2Q_o$ and that during the peak period is: $P_p=100-0,1Q_p$. Variable cost per unit of output *is* €10. Capacity costs per unit are €10 per period. Capacity must be paid during both periods, so capacity costs per unit over the entire day are €20.

The above description of costs underlines a fixed coefficient technology (Leontief production function), since to produce one unit of output requires 1 unit of variable input and 1 unit of capacity [there is no substitution between capacity (capital) and variable inputs (labor)].

1. If the existing capacity is 500 units, what should be the socially optimal prices during the peak and the off-peak period? How much each group consumes?
2. In the above setting what would the optimal capacity be? At the optimal capacity, what should be the socially optimal prices during the peak and the off-peak period? How much each group consumes?

Homework

We assume that peak and off-peak periods have equal length (12h a day). The demand for electricity during the off-peak period is: $P_o=60-0,3Q_o$ and that during the peak period is: $P_p=80-0,2Q_p$. Variable and marginal cost per unit of output *is* €15 (MC=AC=15). Capacity costs per unit are €7,5 per period. Capacity must be paid during both periods.

1. If the existing capacity is 200 units,
   i. Create a diagram showing the Demand curves during the two periods, and the supply curve of the utility.
   ii. What should be the socially optimal prices during the peak and the off-peak period?
   iii. How much each group consumes?
   iv. Does the utility make profits or losses? Calculate the profits (or losses) and show the corresponding area in your graph.
2. In the above setting is the existing capacity optimal? If not, what do you suggest? To what level should capacity be increased? Explain your answer without any calculations.

Exercise on allocation of a depletable resource in two periods

Exercise 1.

Assume that a finite stock of a nonrenewable resource will be extracted over the course of two periods: period 1, representing the current period, and period 2 representing the future. We assume a real discount rate of r = 10%. Demand in each period is given by

$$P_t = 90 - \frac{1}{2} q_t$$

where P_t is the per-unit price and q_t is the quantity of extraction and consumption in period t, with t = 1,2. Furthermore, we assume that the marginal extraction costs is constant and equal in both periods at *MCt =€20*.

g. Calculate the maximum amount of the resource demanded in each period (without considering the existing stock).

Assume that the initial stock of the nonrenewable resource is Q = 70 units,

h. Calculate the quantities produced and consumed at the equilibrium in each period taking into account the existing stock).
i. Calculate the equilibrium price at each period.
j. Calculate the marginal user cost in each period.
k. Illustrate diagrammatically the market equilibrium in the first period showing the MUC.
l. Is there any relationship between the MUC in the first period and the MUC in the second period?

Exercise 2:

Allocation over two periods of a depletable resource with increasing marginal cost of extraction

Assume that a finite stock of a nonrenewable resource will be extracted over the course of two periods: period 1, representing the current period, and period 2 representing the future. Net benefits in both time periods are in inflation-adjusted euros, and for ease of calculation, we will convert any net benefits generated in period 2 into a present value by assuming a real interest / discount rate of r = 10%. For simplicity, we assume that an extracted unit of resource can be immediately consumed without any further need of processing. Demand in each period is given by

$$P_t = 8 - 0{,}4q_t$$

where P_t is the per-unit price and q_t is the quantity of extraction and consumption in period t, with t = 1,2.
Assume that the initial stock of the nonrenewable resource is Q = 20 units,

Furthermore, we assume that marginal extraction costs increase with cumulative extraction. That is, in period 1, assume marginal extraction costs are $MC_1 = Q_1$ which means that the first unit of the resource stock could be extracted for €1, the second unit for €2, the third for €3, and so forth. Entering period 2, Q_1 units of the resource will have already been extracted, so marginal extraction costs in period 2 will be $MEC_2 = Q_1 + Q_2$. This means that if, for example, 4 units of the resource were extracted in period 1, then the first unit produced in period 2 (the fifth unit overall) would cost €5, and the second unit produced in period 2 (the sixth unit overall) would cost €6.

In this formulation, the costs of extraction in period 2 now critically depend on the amount extracted in period 1. An additional unit extracted in period 1 increases the cost of *every* unit eventually produced in period 2 by €1 (relative to what second period costs would have been if an additional unit were not extracted in period 1).

Without taking into account the resource constraint:

a. Calculate the quantities of the resource extracted in each period
b. Illustrate diagrammatically the market equilibrium in each period separately.
c. Is the resource exhausted? If not why?
d. Calculate the price at each period
e. Calculate the marginal user cost in each period
f. How can you explain the value of the MUC of the second period?
g. Is there any relationship between the MUC in the first period and the additional MC in the second period (above the MC in the first period)?