

AAE / ECON / FOREST 531 (Natural Resource Economics)

Homework #4

Due in Class on Thursday, November 13, 2008

1. **Biodiversity conservation.** Consider a competitive land market defined by an inverse demand function for development ($P = P_d - m_d q$) and a supply function of land ($P = P_s + m_s q$), where P is price, q is quantity of land (acres), and P_d , P_s , m_d , and m_s are positive parameters. There are 100 total acres available in this market and all undeveloped land is considered open land. Suppose a conservation group enters the land market to purchase land for biodiversity reserves, creating a new inverse demand function of $P' = P_d' - m_d q$. Suppose the parameter α represents the ecological value of open land as a fraction of reserves, where $\alpha = 0.8$.
 - a. What is the ecological value of this land market in the absence of the conservation group?
 - b. Suppose the following numerical values for all parameters: $P_d = 10$, $P_d' = 12$, $P_s = 1$, $m_d = m_s = 0.1$. If the conservation group enters the land market, how much land will they buy (q_c) and what is the total change in conservation (ΔC)?
 - c. Suppose the following numerical values for all parameters: $P_d = 12.25$, $P_d' = 15.25$, $P_s = 1$, $m_d = 0.15$, and $m_s = 0.1$. If the conservation group enters the land market, how much land will they buy (q_c) and what is the total change in conservation (ΔC)?
 - d. Compare the answers to parts b and c and intuitively explain any differences. How do your answers to parts b and c change if α increases to 0.95? Explain.

2. **Competitive vs. Monopolistic Extraction.** Suppose the price of oil is given by $p_t = a - bq_t$, where q_t is the rate of oil extraction in period t , $a = 1$ and $b = 0.1$. The initial oil reserve (R_0) equals 75, the remaining oil reserves change according to $R_{t+1} = R_t - q_t$, and there are no extraction costs. Further, assume a 5% discount rate.
 - a. Suppose the oil industry is competitive, and each firm is interested in maximizing the present value of net revenue over the horizon $t = 0, 1, \dots, T_C$. Using Hotelling's rule, plot the optimal time path of extraction (q_t) and price (p_t) for the life-cycle of the resource using Excel.
 - b. Suppose that a monopoly controls oil extraction and is interested in maximizing the present value of net revenue over the horizon $t = 0, 1, \dots, T_M$.
 - i. Starting from the monopolist's optimization problem, derive Hotelling's rule for monopolists: $MR_t = (1 + \delta)MR_{t+1}$, where MR_t is the monopolist's marginal revenue in time t .
 - ii. Using Hotelling's rule for monopolists, plot the optimal time path of extraction (q_t) and price (p_t) for the life-cycle of the oil resource using Excel.
 - c. Compare the optimal time path of extraction and price for the competitive industry and the monopolist. Is $T_C > < T_M$? Provide intuition.

3. **Landfill Management.** Consider the problem of a landfill manager acting on behalf of society. The initial amount of space available in the landfill in year 0 is S_0 . The manager must decide how much fill X_t to put in the landfill in each year until the landfill is filled (it is filled when $S = 0$). Landfill space evolves over time according to $S_{t+1} = S_t - X_t$. The

inverse demand for landfill dumping is given by $P_t = a - bX_t$, where P_t is the price charged per unit garbage. The demand is downward sloping because it is possible to recycle and reuse waste, and because people can change their use of materials as the cost of landfilling increases; for instance, they can switch their use of diapers from disposables to cloth. With this demand curve, the benefit of landfill dumping at any point in time is $aX_t - (b/2)X_t^2$.

- a. Set up the dynamic optimization problem of the landfill manager and derive the first-order conditions.
- b. What should be the price charged per unit garbage at each point in time? Provide the economic intuition behind this result.
- c. Would residents dump the optimal amount of garbage if they were not charged a per unit landfill fee? The absence of a landfill fee applies, for instance, in communities that have curbside pickup, and pay for garbage collection through property taxes. Formally state (give a mathematical expression) the amount of garbage that would be dumped in each period in the absence of a landfill fee.