AAE 343 Discussion Section 8 – Solutions

March 29, 2019

a. Housekeeping

1. Midterm questions?
   a. Overall nice work!- grades were pretty good.
   b. Don't get too discouraged if it didn't go as well as you'd like – while we'll build on these earlier concepts, the second exam will only cover material started since Spring Break
   c. Any re-grade requests directly to Dr. Johnston in writing by **TUESDAY**.

2. Resetting the stage moving forward…
   a. We've been thinking mostly about the pursuit of economic efficiency in the face of *environmental* issues.
      - Key idea: to attain social optimum, need to account for externalities across firms/households/agents.
   b. The next few weeks are going to focus on *resource* economics – how to optimally use finite resources over time.
      - Key idea: to attain social optimum, need to account for externalities of resource use across time.
   c. Closer to end of the course, we will think about climate change by joining ideas that we've developed from dealing with both *environmental* and *resource* issues.
      - Account for inter-agent and temporal externalities together

b. *Nonrenewable* Resource Extraction

1. Nonrenewable – a fixed stock of the resource exists today, and won't regenerate in the "long-run". Common examples: oil, minerals, groundwater
2. As always, we're going to assume the efficient market outcome occurs, so $P = MC$.
   a. Note: this assumption may be particularly reasonable in the nonrenewable resource context – many are privately owned and extracted, then traded on rather competitive markets
3. **Marginal costs** include *user costs* and *extraction costs*: $MC = MUC + MEC$.
4. The **marginal net benefit** is the difference between the price and marginal extraction costs: $MNB = P - MEC$.
5. Marginal user costs are the ***opportunity cost of using a resource today*** (i.e., the discounted, forgone net benefit of instead using that unit in the future).
6. If you do some nifty algebra using the equations in 2, 3, and 4, you'll see that $MNB = MUC$. In words: *the net benefit of extracting today is equal to the opportunity cost of extracting tomorrow.*
7. *Hotelling's Rule*
   a. To maximize the value from extracting a resource stock over time, prices must increase at the rate of interest
8. The rising price path reflects the increasing scarcity of the stock
9. More technically, the present value of the marginal net benefits of a resource must be constant over time. That is,

$$\frac{MNB_0}{(1+r)^0} = \frac{MNB_1}{(1+r)^1} = \frac{MNB_2}{(1+r)^2} = \cdots = \frac{MNB_t}{(1+r)^t}$$

Problem 1 *Getting your hands on Unobtanium* – Suppose you own an Unobtanium mine and will be extracting this precious resource in two time periods, "today" and "tomorrow." The demand for Unobtanium in each period is $MB_t = 50 - \frac{1}{4}Q_t$, where Q_t is the quantity of Unobtanium extracted in period t. Your marginal cost for extracting this rare Pandorian mineral is constant at $MC_t = 20$.

a. Assume (absurdly) the supply of Unobtanium on Pandora is infinite. What would be the efficient quantity of the mineral to extract today? Show this graphically.

b. Now suppose, more realistically, that your Unobtanium mine has a finite stock of 200 units. Consider that you have two periods to extract Unobtanium before you have to leave Pandora. Let the period today be $t = 0$ and your last period on the planet be $t = 1$. How much Unobtanium would you extract today to maximize net benefits if the discount rate is 10%?

c. Would you extract more or less today if the discount rate was 1%?

Problem 2 *Frac'ing Dane* - Dane County just decided to allow a mining company to extract frac sand over a two year period. Demand for frac sand is P = 200 – Q, marginal extraction costs are $10 per ton, the discount rate is 10 percent, and the total stock of the resource is 100 tons.

a. Write an expression for the marginal net benefit in period 0.

b. Write an expression for the net present value of the marginal net benefit in period 1.

c. Graph the two-period consumption.

d. What is the efficient extraction of resources in period 0 and period 1?

e. What is the (undiscounted) marginal net benefit in each period? The marginal user cost?

f. If the discount rate decreases, how does consumption in the first period shift?

Problem 3 *Very stylized and incomplete thought exercises* – As you probably noticed, we have thus far assumed the existence of property rights, resulting in private ownership of resources. As mentioned towards the beginning, this is often the case – especially in scenarios involving mining. But let's consider groundwater now – a resource that is typically open-access and sometimes non-renewable.

a. *The commons and temporal externalities:* Imagine yourself a farmer who draws from the local groundwater aquifer to irrigate your crops. Your neighbors do the same. The aquifer does not replenish itself quickly enough to notice. Without solving a formal model, does your economic intuition suggest that the water will be exhausted faster or slower than the scenario where you alone have property rights to the aquifer and can sell groundwater to your neighbors at a competitive market price?

b. *Storage of nonrenewable resources:* Suppose you (and your neighbors) have an affordable means to store groundwater indefinitely after it is extracted. If the market price for irrigation water is sufficiently high, how long might we expect it to take for all the groundwater to be extracted?

Question 1 Consider a two-period Hotelling model with an arbitrary but positive discount rate. The model predicts that we will consume less than half of the nonrenewable resource in the second period (answer graded).

Question 2 Higher discount rates are associated with _____ exhaustion of a natural resource (answer graded).