ECO6143 Natural-Resource Economics
Final exam April 2007
University of Ottawa
Professor: Louis Hotte
Time allowed: 3h00m

1. Population size, conflict and sustainable resource use (25 points)

When a new track of land is being settled at some remote location, settlers have a choice between a sustainable use of the land or land mining. A sustainable use produces a constant flow of output y while mining produces an instantaneous gain of S. In both cases, the unit price of the output is equal to 1. Given an interest rate of r, we assume that a sustainable use of the land is *a priori* preferable with $y/r > S$.

The problem is that if the first settler to arrive decides for a sustainable use of the land, he must also protect it from other claimants. We assume that there are n claimants, including the first settler. If claimant i expends effort level x_i to appropriate the track of land, he has a probability

$$\frac{x_i}{\sum_{j=1}^{n} x_j}$$

of becoming the owner, in which case he benefits from the sustainable use of the land forever. Assuming that the unit cost of effort is c for all claimants, the *expected* value of the contest for a sustainable use for claimant i is thus

$$V_i = \frac{y}{r}\frac{x_i}{\sum_{j=1}^{n} x_j} - cx_i. \tag{1}$$

a) Assume for now that the first settler decides for a sustainable use of the land. He thus enters into a contest with $n-1$ other claimants. Derive the symmetrical Nash equilibrium level of effort x_i that will be expended by each contestant as a function of y, r, c and n.
b) Calculate the equilibrium value V_i^* for the first contestant of a sustainable use of the land.
c) Suppose that n is a measure of a country's population size. Compare V_i^* with S and show that as the population size increases, it becomes less likely that settlers will opt for a sustainable use of land in new settlements.

2. Property regime (25 points)

The following is an excerpt from Fitzpatrick (2006), "Evolution and Chaos in Property Rights Systems: The Third World Tragedy of Contested Access", *Yale Law Journal*.

> Law-and-economics orthodoxy suggests that the emergence of property rights is a story of evolutionary success. In Harold Demsetz's classic formulation, rising resource values lead to the creation of private property rights when the benefits of private ownership outweigh its costs. While this formulation has

> been modified and elaborated over time, particularly in relation to common property regimes, its proponents continue to apply a basic cost-benefit analysis to predict the evolution of property systems toward efficiency and net social welfare. In these terms, property is simply another legal institution that evolves toward efficiency under the influence of competitive conditions.
>
> While most of the examples supporting Demsetz's thesis have been taken from North America and England, the prognosis for the rest of the world should also be relatively optimistic. Because rising populations and trade opportunities increase resource values, and thus increase the benefits of authorized ownership and use, a general transition should take place from open access to legal or norm-based regimes with clear property rights and rules. These regimes may have private or common property elements, but the result should be the same: a move from wasteful resource consumption and competition to a system of investment, sustainable resource consumption, and internalization of unwanted spillover effects. Moreover, once such a beneficial regime is established, the likelihood of reversion to open or contested access will be relatively low because the benefits of property are continuous, and other institutions emerge to protect its existence.
>
> Outside of more developed economies, this optimistic picture does not appear to be matched by reality.

Discuss why the author thinks that Demsetz's picture is too optimistic and how this leads us understand the problem of resource degradation in the Third World today.

3. A common property resource with heterogeneous users (25 points)

A common-property resource is accessed by two users A and B. The total output is given by quadratic output function

$$f(x) = (2 - x)x,$$

where x denote the sum of individual input effort, i.e. $x = x_A + x_B$. The users differ by the cost of their effort. The respective total costs are given by

$$\begin{aligned} c_A(x_A) &= \frac{1}{2}x_A^2, \\ c_B(x_B) &= x_B^2. \end{aligned}$$

(a) Find the efficient allocation of effort x_A^* and x_B^* between the two users. Provide a brief economic interpretation. Calculate the total profit level.

(b) Find the (non-cooperative) Nash equilibrium individual level of effort x_A^{FA} and x_B^{FA} assuming a free access regime. Assume that each user's average product of effort is equal to the global average product of effort $f(x)/x$. Calculate the individual profit levels. Compare with the efficient allocation found in (a) and interpret briefly.

(c) Suppose that the users get together in order to assign *non-transferable* quotas on each other's effort level equal to the efficient level, i.e. $q_A^{NT} = x_A^*$ and $q_B^{NT} = x_B^*$. Participation is purely voluntary *ex-ante*. But once it is agreed upon, each user strictly adheres to its quota level, i.e. there is no enforcement problem. Using the free access Nash equilibrium as the benchmark, show that user B will not agree to participate in this scheme. (NB This is essentially equivalent to a non-transferable quota scheme without subsidy.)

(d) Suppose now that quotas are transferable. They are initially distributed in the same proportion as the proportion of individual effort that occurs in the non-cooperative free access equilibrium derived in (b), i.e.

$$\begin{aligned} q_A^T &= \frac{x_A^{FA}}{x^{FA}} x^*, \\ q_B^T &= \frac{x_B^{FA}}{x^{FA}} x^*, \end{aligned}$$

where $x^{FA} = x_A^{FA} + x_B^{FA}$ and $x^* = x_A^* + x_B^*$. (This is similar to a *grandfather clause* in which the worst offender actually gets a higher share of quotas.)

i) Show that there are gains from trade such that user A buys $q_B^T - x_B^*$ units of effort quotas from B, thus leading to an efficient allocation of effort. (Hint: You must show that the increase in profit for user A are larger than the drop in profits for user B. Hence there exists a price range for which both will gain from trading $q_B^T - x_B^*$ quotas.)

ii) Show that both users will choose to participate in this scheme once we account for the transfers due to the quotas' price level.

(e) The above results can be generalized to common property resource users with heterogeneous characteristics. Discuss the consequences for the possibility of reaching a CPR sharing agreement.