Population size, conflict and sustainable resource use

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 $p(d)$, where d is distance to market. Given an interest rate of r, we assume that a sustainable use of the land is *a priori* preferable with $p(d)y/r > p(d)S$. Production costs are nil.

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

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

If the first settler opts for mining the land, he does not have to incur any appropriation cost.

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, d and n.*

The problem of the settler is

$$\max_{x_i} V_i = \frac{p(d)y}{r}\frac{x_i}{x_i + x_{-i}} - cx_i. \tag{2}$$

The FOCs are

$$\frac{\partial V_i}{\partial x_i} = \frac{p(d)y}{r}\frac{x_{-i}}{(x_i + x_{-i})^2} - c = 0, \quad \forall i. \tag{3}$$

Assuming a symmetrical Nash equilibrium in which $x_1 = x_2 = ... = x_n \equiv x$, we have

$$\frac{p(d)y}{r}\frac{(n-1)x}{(nx)^2} - c = 0, \tag{4}$$

which yields

$$x^N = \frac{n-1}{n^2}\frac{p(d)y}{cr} \tag{5}$$

This represents the individual level of effort expended by each settler in order to appropriate the land, given that the first settler has opted for a sustainable use.

b) *Calculate the equilibrium value V_i^* for the first contestant of a sustainable use of the land.*

Since all contestants choose the same effort level, we have $x_i/(x_i + x_{-i}) = 1/n$. Hence

$$V_i^* = \frac{1}{n}\frac{p(d)y}{r} - \frac{n-1}{n^2}\frac{p(d)y}{r} = \frac{1}{n^2}\frac{p(d)y}{r}. \tag{6}$$

c) *Suppose that n is a measure of a country's population size. Compare V_i^* with $p(d)S$ 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.*

The settler opts for a sustainable use if and only if $V_i^* > p(d)S$, i.e.

$$\frac{1}{n^2}\frac{p(d)y}{r} > p(d)S. \tag{7}$$

Since V_i^* decreases with n, as n increases, it becomes less likely that land will be used in a sustainable manner.

d) *Analyze the effect of distance to market on the type of resource use and appropriation expenditures.*

In this model, the sole effect of distance to market is to reduce the resource price $p(d)$, with $p'(d) < 0$.[1] From (7), we see that changes in resource prices have no effect on the decision to mine the resource or not. This is because higher prices increase both the value of a sustainable use and resource mining at the same rate. Hence, one would observe neither more, nor less conflict as one moves away from the market towards the frontier.

From (5), we note that as the resource price decreases, appropriation expenditures decrease. Hence, although equilibrium property rights are neither more, nor less secure as one moves away from the market, we could say that the "severity" of conflict goes down for a sustainable land use.

[1] In Hotte (2001), distance to market also affects a contestant's effectiveness of eviction efforts.