Resource Economics – Institutions

Lecture 12: Renewable resources and endogenous institutions

The following is a simplified version of the model presented in Copeland and Taylor (2009) "Trade, Tragedy, and the Commons". The bio-economic model is of the standard Gordon-Schaefer type, equation (1) and (2), and the focus is throughout on the steady state $G(S) = H$.

$$G(S) = rS\left(1 - \frac{S}{K}\right) \tag{1}$$

$$H = \alpha LS \tag{2}$$

implying that in steady state:

$$S = K\left(1 - \frac{\alpha L}{r}\right) \tag{3}$$

Effort L is the aggregate labour devoted to harvesting the renewable resource. Total population size is N and the alternative occupation is manufacturing, a CRS technology which pays w per unit of labour. The individual household thus has the following revenue:

$$R = p\alpha lS + (1 - l)w \tag{4}$$

Two assumptions: First, at high stock levels, resource rents are positive:

$$\pi^C = p\alpha S - w > 0 \quad \text{for some } S \leq K \tag{A-1}$$

At high stock levels, everybody would like to spend his or her entire time harvesting the resource. However, the second assumption is that there is overcapacity in the sense that if everybody were to harvest, the stock would be extinguished. That is:

$$\frac{\alpha N}{r} > 1. \tag{A-2}$$

In equilibrium, the individual equates the fine F from cheating, weighted by the probability of being detected ρ, with the instantaneous gains from cheating:

$$\rho F = \pi^C - \pi \tag{5}$$

where π is the return to behaving (harvesting with the individual effort level l, i.e. $\pi = p\alpha lS - wl$). The fine F is set equal to the annuity of being excluded from harvesting the resource, which in steady-state is $F = \frac{\pi}{\delta}$. Aggregate effort is given by $L = N \cdot l$, so that the lowest level to which effort can be restraint is[1]

$$L^T = \frac{\delta}{\delta + \rho} N \tag{6}$$

It is however not necessarily the case that the manager always enforces the effort level L^T. On the one hand, it is possible that L^T is so high compared to the value of the resource, that employing L^T

[1] Inserting $F = \frac{\pi}{\delta}$ in (5), using $\pi^C = \frac{\pi}{l^*}$, and canceling π yields: $\rho F = \pi^C - \pi \quad \Rightarrow \quad \rho\frac{\pi}{\delta} = \frac{\pi}{l} - \pi \quad \Rightarrow \quad \frac{\rho}{\delta} = \frac{1}{l} - 1 \quad \Rightarrow \quad \frac{\delta+\rho}{\delta} = \frac{1}{l}$

would imply negative rents. The best that the manager can do in this case "is to throw up his hands and allow agents to harvest all they want". Effort will enter until all rents are dissipated (the revenue from time spent harvesting equals its opportunity cost from time spent in manufacturing), denote this level L^{OA}.

$$L^{OA} = \frac{r}{\alpha}\left(1 - \frac{w}{p\alpha K}\right) \tag{7}$$

On the other hand, it is possible that the resource is so valuable that the first-best optimal level of effort L^* is higher than L^T. In other words, L^* is the (interior) result of an unconstrained maximization of $\int_0^\infty [p\alpha LS + w(N-L)]e^{-\delta t}\mathrm{d}t$ subject to (1). It is implicitly defined by the familiar relationships:

$$\delta = G'(S^*) + \frac{\alpha L^*}{p\alpha S^* - w} \quad \text{(a)} \qquad \text{and} \qquad L^* = \frac{g}{\alpha}\left(1 - \frac{S^*}{K}\right) \quad \text{(b)} \tag{8}$$

As a result, the resource manager is faced with the following "incentive constraint":

$$L \geq \min\{L^{OA}, L^T\} \tag{9}$$

Note that while L^T is independent of the price p, the open access level of effort L^{OA} and the unconstrained first-best level of effort L^* are increasing in p. As p grows very large, $L^{OA} \to \frac{r}{\alpha}$ (confer equation 7) and $L^* \to \frac{r+\delta}{2\alpha}$. The latter can be deduced from the fact that as the price rises without bounds, the resource becomes so valuable that the stock-effect in the cost function loses its significance, and condition (8a) simplifies to $\delta = G'(S^*) = r - \frac{2r}{K}S^*$, which can then be substituted into (8b).

If the incentive constraint (9) binds, de facto open access will result when $L^T \geq L^{OA}$. *Hardin economies* are characterized by $L_H^T \geq \frac{r}{\alpha}$, so that they never resolve their "tragedy of the commons", irrespective how valuable the resource is.

For *Ostrom economies*, $L_O^T < \frac{r}{\alpha}$ so that there exists a price p^+ for which harvesting restrictions are successfully implemented and rents are being generated. However, the enforcement power of Ostrom economies is not sufficient to achieve the first-best, that is $L_O^T \geq \frac{r+\delta}{2\alpha}$.

Finally, *Clark economies* are characterized by $L_C^T < \frac{r}{\alpha}$ and $L_C^T < \frac{r+\delta}{2\alpha}$. When the price rises above p^{++}, the resource is very valuable and calls for high effort so that the first best can be implemented (since both effort needs to be restricted less and the threat of exclusion lures larger), even though the manager in a Clark economy would have sufficient power to push effort down to the level L_C^T.

Proposition (Number 5 in Copeland and Taylor, 2009): Suppose an elimination of trade frictions leads to an price increase from p^{old} to p^{new}, then this will

(i) Reduce income in a Hardin economy

(ii) Increase income in Clark or Ostrom economy when $p^{old} > p^+$

(iii) Decrease income in Clark or Ostrom economies when $p^{old} < p^+$, but if $p^{new} > p^+$, then trade liberalization leads to the emergence of a management regime and increases income. For Clark economies, if $p^{new} > p^{++}$, management is fully efficient.

References

Copeland, B. R. and Taylor, M. S. (2009). Trade, tragedy, and the commons. *American Economic Review*, 99(3):725–49.