Resource Economics – Renewable Resources

Lecture 8: Rent dissipation and Regulation

Read Perman et al. (2003, ch.17) and Smith and Wilen (2003).

3 Rent dissipation

Scenarios of unregulated competitive harvesting come in many different forms, but they all share one aspect: the resource users do not fully take the self-reproducible character of the resource into account. The "tragedy of the commons" (Hardin, 1968) is that the gains from harvesting one more fish are private, while the cost (in terms of a reduced stock size) are borne by all.

3.1 Two simple ways of modeling the open-access equilibrium

The "bionomic" equilibrium in the Gordon-Schaefer model

Under open access effort will enter the fishery until all rents are dissipated. Stock dynamics are given by (1) and effort dynamics are given by (2), where $\pi = pqES - wE$ and $\gamma > 0$ is parameter determining the adjustment speed.

$$\dot{S} = gS(1-S) - qES \tag{1}$$

$$\dot{E} = \gamma\pi \tag{2}$$

Equilibrium ($\dot{S} = 0$, $\dot{E} = 0$) then implies:

$$S^{OA} = \frac{w}{pq}, \qquad E^{OA} = \frac{g}{q}(1 - S^{OA})$$

A characterization in terms of harvest

The economic equilibrium condition is therefore $pH(E,S) = c(E)$. Using equations $H = qE^{1-\alpha}S^{\beta}$ and $c(H,S) = w\left(\frac{H}{qS^{\beta}}\right)^{\frac{1}{1-\alpha}}$ as in the last lecture, this implies:

$$pH = c(H,S) \Rightarrow \tag{3}$$

$$H^{OA} = \underbrace{\left(\frac{p}{w}\right)^{\frac{1-\alpha}{\alpha}} q^{\frac{1}{\alpha}}}_{\tilde{A}} S^{\frac{\beta}{\alpha}} \quad = \tilde{A}S^{\frac{\beta}{\alpha}} \tag{4}$$

Compare this to the optimal harvest level:

$$H^{*} = \underbrace{\left(\frac{(p-\mu^{*})(1-\alpha)}{w}\right)^{\frac{1-\alpha}{\alpha}} q^{\frac{1}{\alpha}}}_{A} S^{\frac{\beta}{\alpha}} \quad = \quad AS^{\frac{\beta}{\alpha}} \tag{5}$$

Clearly since $0 < \alpha < 1$ and $\mu^{*} > 0$ we have that $H^{*} < H^{OA}$ and consequently $S^{*} > S^{OA}$.

In other words, open access can – as the optimal control problem with an infinite discount rate – yield only a short-term profit as the fish stock is harvested down to the open-access level S^{OA}. Note that the open-access stock level will be inefficiently low but positive, if there is stock-dependency in the harvesting cost. Conversely, this implies that the fishery will be extirpated when the stock size has no influence on the harvesting cost.

4 Regulation

4.1 Incentive-based regulations

Suppose the regulator can set a harvest tax τ. The open access equilibrium then becomes:

$$(p-\tau)H = c(H,S)$$
$$\Rightarrow H^{\tau} = \left(\frac{p-\tau}{w}\right)^{\frac{1-\alpha}{\alpha}} q^{\frac{1}{\alpha}} S^{\frac{\beta}{\alpha}} \tag{6}$$

From inspecting (7) and (5) it is clear that a tax $\tau^* = p\alpha + (1-\alpha)\mu^*$ recovers the socially optimal harvest level.

Similarly, the regulator can set a total quota $Q = \sum_i^N Q_i$, distribute it among all participants in the fishery and allow tradability (hence ITQ – individually tradable quotas or catch shares). Open access equilibrium implies that each agent equates (where ρ denotes the opportunity cost of holding a share of the total quota Q_i):

$$(p-\rho)H = c(H,S)$$
$$\Rightarrow H^{itq} = \left(\frac{p-\rho}{w}\right)^{\frac{1-\alpha}{\alpha}} q^{\frac{1}{\alpha}} S^{\frac{\beta}{\alpha}} \tag{7}$$

By setting the appropriate total quota Q^* the quota price will be $\rho^* = p\alpha + (1-\alpha)\mu^*$ and recover the socially optimal harvest level.

The informational requirements of such a management would be formidable, of course. Similarly, the assumptions of the model are heroic. Nevertheless, incentive-based regulations get at the heart of matters, in contrast to many command-and-control regulations that merely address the symptoms of overfishing.

4.2 Command-and-control measures

Total catch quotas (TAC) are maybe the most ubiquitous tool of fisheries management in the developed world. If enforced, they effectively safeguard the stock, but they invite a “race to fish” where each fisher tries to catch as much as possible as fast as possible before the total quota is filled. In some cases, such a “regulated open access” may in fact be even worse than if there were no regulation (Homans and Wilen, 1997). In general, there are many margins along which incentives may “sneak in through the backdoor” (Smith, 2012):

- Age/Size
- Space
- Multi-species issues, bycatch and discarding
- Market inter-linkages

4.3 Marine reserves

The idea of marine reserve originated from a conservationist’ perspective. It is by now framed as a management tool.

The importance of taking biological aspects into account

When modeling space as different "patches" it is important to adequately model dispersal. There are density-dependent aspects and environmental aspects (ocean currents, life-history dependent habitats etc) to it. One of the simpler models is a uni-directional "sink-source" setup: Creating a reserve in the sink patch increases biomass but reduces harvest, but creating a marine reserve in the source patch may lead to a "double payoff" (Sanchirico and Wilen, 2001)

The importance of taking economic incentives into account

Smith and Wilen (2003) look at the example of the Californian sea urchin fishery and calibrate an elaborate spatial-temporal model on a large dataset of discrete choice occasions. They then couple the derived functional relationship between expected revenue and location choice to a detailed biological model to simulate the effects of establishing marine reserves in different patches.

They contrast their model with a "non-econ" model that ignores behavioral adaptations. Whereas the latter predicts increases in harvest in over half of the patch closure options, the former predicts a drop in steady-state harvest under any option. There are two main effects: First, non-economic models that are calibrated on the draw down phase towards open access equilibrium over-predict the extent of overexploitation. Second, high cost or high risk areas form de facto reserves that contribute to biomass production in a way which is not revealed by simple assumption about uniform effort distribution. Biomass is predicted to increase also in the "econ" model, but different patches are considered to be least costly.

References

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