Externalities : (g) Common Property Resources

Common property resources with free access are examples of externalities. The externality problem is that there is some pool, or stock, to which everyone has free access. But the greater the number of firms accessing the common property resource, the lower each firm's yield. A pool of oil underneath the ground is a common property resource. Any firm drilling for oil (from a location on ground above the pool of oil) will be able to get some of the oil in the pool. But as the number of oil wells drilled rises, the yield from each well falls, since all the wells are pumping from the same finite stock of oil.

Historically, villages often had a plot of land called the "commons" on which anyone could graze her or his livestock. This land was a common property resource with free access. Any farmer could graze cattle there. But the more cattle grazing, the less each animal can eat, since all the animals are grazing the same finite stock of grass.

The stocks of fish in the oceans are common property resources as well. If there is free access, any boat can fish. The more boats fishing for the same stock, the smaller will be each boat's catch.

Mathematically, let

N : number of firms accessing the resource

$f(N)$: the yield of **each** firm

c : the (private) cost of each firm

p : the price of the output produced by the firm

so that, in the oil example, c is the cost of drilling a well, $f(N)$ is the average output (in barrels of oil per year) of each well, and p is the price of oil (per barrel). The externality stems from the fact that the yield per firm decreases with the number of firms exploiting the resource

$$f'(N) < 0 \tag{1}$$

The profit of each firm is its revenue minus its costs. So if π is the profit of **each** firm, then

$$\pi = pf(N) - c - T$$

where T is any extra taxes, fees, or rent the firm might have to pay. (These fees or taxes will be considered below, as possible ways of internalizing the externality.)

The key assumption, which leads to an externality problem, is that there is **free entry**. That is, any firm can use the common property resource, if it finds it profitable to do so. This was the case with the village commons : anyone in the village had the right to use the commons for grazing. It also is the case for fishing outside of countries' territorial waters : any boat can choose to fish in these waters.

As long as firms make positive economic profits, they will enter. Note that, since $f(N)$ is a decreasing function of the number of firms, the profit π of each firm is a decreasing function of the number of firms in the industry. Equation (1) shows that

$$\frac{\partial \pi}{\partial N} = -pf'(N) < 0 \tag{2}$$

As long as there are positive profits being earned from exploiting the common property resource, firms will be willing to enter. How many firms will choose to enter? The equilibrium condition is that profits of the marginal firm be zero : as long as profits are positive, firms will want to enter, and, by assumption, they cannot be prevented from entering.

This equilibrium condition — the zero profit condition — can be written

$$pf(N) = c + T \tag{3}$$

This zero profit condition (3) defines the number of firms which enter the industry : since $f' < 0$, the number of firms will be a **decreasing** function of the cost c and of any taxes T, and an increasing function of the price of the output p.

If there is free access, and there are no licence fees, taxes or rents, then $T = 0$, and the number of firms N^F is the solution to the equation

$$pf(N^F) = c \tag{4}$$

The total rents earned from the resource, the net surplus, is the total value of the yield, minus the costs of getting it. (For example, the total profit from the oil pool is the revenue from the oil produced, minus the cost of drilling the wells).

$$S = pf(N)N - cN \tag{5}$$

As before, it will be assumed that the market for the output of this industry is perfectly competitive, so that total industry rents S is the measure of the net value to society of the industry production . Then the efficient number of firms N^* is the number which maximizes these total rents. To maximize S with respect to N, differentiate equation (5) with respect to N, and set the derivative equal to zero. So N^*, the efficient number of firms, is the solution to the equation

$$pf(N^*) + pf'(N^*)N^* - c = 0 \tag{6}$$

As long as $f'(N) < 0$, then $N^F > N^*$, as shown in figure 6 : free access leads to over–exploitation of the resource.

In fact, free entry leads to $S = 0$, since $S = N[pf(N) - c]$ and $pf(N^F) - c = 0$. All the rent from the common property resource will be dissipated by free entry.

Now if the marginal damage due to entry is defined by

$$MD = -pf'(N^*)N^* > 0 \tag{7}$$

then the efficiency condition (6) can be written

$$pf(N^*) = c + MD \tag{8}$$

Note that MD defined this way is exactly the damage done, at the margin, by entry. The term $-pf'(N)N$ is the value of the reduction in profit of each of the existing firms, caused by a small increase in the number N of firms.

Equation (8) also shows that the equilibrium could be made efficient by making a firm pay a fee of $T = MD$, in addition to its operating costs c.

So how could the efficient outcome be attained? One solution would be having a single firm own the entire resource — provided that the resource was small enough, relative to world markets, that the firm would still have no control over the price p. A single owner would choose the number of divisions N so as to maximize its profits from the whole resource, S. It would take into account the effects of one more division on the yield of all the other divisions, since it owned them all.

Of course this solution requires that free entry be controlled. Having a single firm control the property resource only works if it can prevent other firms from exploiting the resource. This may not always be possible, as in the example of the fishery.

Another possibility would be for one single company to own the whole resource, and to rent it out to other firms to use, charging an entry fee to each firm which used the resource. If N firms entered, what entry fee would each be willing to pay? The largest fee F a firm would be willing to pay was one which reduced its overall profit margin to zero, one such that $pf(N) = c + F$. So if the resource's owner let in N firms, then the fee it could charge per firm would be $pf(N) - c$, so that its total rentalincome would be

$$FN = (pf(N) - c)N = S \tag{9}$$

The resource's owner would want to maximize its total income, and to do so it would rent to N^* firms at a fee of $pf(N^*) - c$ per firm.

Or a government agency could also induce an efficient outcome, by charging a licence fee of MD for each firm, or by restricting entry to N^* firms. These solutions (having a landlord rent out access to the resource, or having the government charge licence fees or set a limit on the number of firms) will only work if it is physically possible to exclude firms from entry.

So common property resources are just an example of negative externalities. As in the general case, efficiency dictates a level of activity at which $MB = MPC + MD$, and individual agents will ignore MD unless they have an incentive to "internalize" this externality.

Common property resources also indicate that the problem of externality can be viewed as the problem of a **missing market**. One of the remedies proposed above was assignment of property rights to the common property resource : instead of making the commons free for all to use, sell it to someone who will then value the rents earned. What this view shows is that it may be relatively easy to internalize the externality when it is easy to assign ownership (of land, or perhaps of a closed body of water which may be subject to pollution). In other cases, ownership of the common property resource may be impossible to assign (clean air, the stock of codfish in the Atlantic).